Committee Reports Number

Electrical West

With which is consolidated the Journal of Electricity

A McGRAW-HILL PUBLICATION | May 15, 1930 | FIFTY CENTS PER COPY

THE BIG CREEK 2-A PLANT

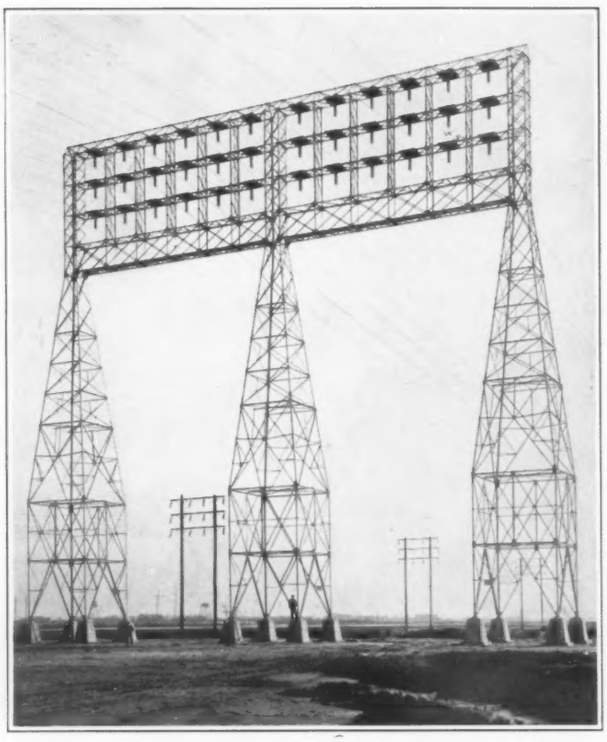
Southern California Edison Company

These two horizontal water wheel generators, largest of this type in the United States, were built by Westinghouse and are rated 45,000 kv-a. and 50,000 kv-a. at 50 and 60 cycles respectively. The selection of Westinghouse machines for this 2-A plant reflects much credit upon the performance of the four Westinghouse water wheel generators in the power company's No. 2 station, which this newer plant supplements.

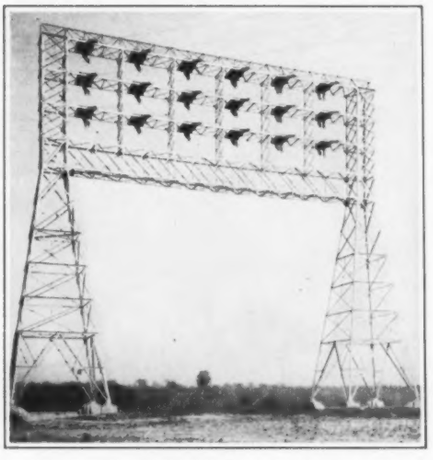
Westinghouse

WESTINGHOUSE ELECTRIC

STEEL marks the Trend in Transmission Structures



Twelve circuit 66-kv. multi-circuit tower on Long Beach to Lighthipe line. Outriggers give these structures a capacity of fourteen circuits.



Six circuit 66-kv. angle tower. Note protected runway providing access to all circuits.

The problem of designing suitable supporting structures for the rapidly increasing number of transmission lines is more and more being met by the use of steel.

Thousands of tons of steel annually go into the fabrication of poles, towers and other transmission-supporting structures. A large portion of this steel is used in Multi-Circuit Towers.

Towers carrying from four to fourteen 66-kv. circuits are now in use in the more developed industrial, residential and agricultural areas in Southern California. These installations have proven so successful, both from an electrical and mechanical standpoint, and in the economies effected in the saving of materials and conserving costs of right-of-way, that Multi-Circuit Towers are being extensively adopted for use in the more congested areas.

Multi-Circuit Towers, poles and other steel transmission-supporting structures are manufactured by the Pacific Coast Steel Corporation. Our engineers and organization will be glad to submit information and data, and give you the benefit of our experience in the design and fabrication of all types of steel transmission structures.

PACIFIC COAST STEEL
CORPORATION

General Offices: Matson Building, San Francisco

Subsidiary of BETHLEHEM STEEL CORPORATION

Los Angeles: Pacific Finance Bldg. Portland: American Bank Bldg. Seattle: Alaska Bldg. Honolulu: Castle & Cooke Bldg.

Export Distributor: Bethlehem Steel Export Corporation, 25 Broadway, New York City.

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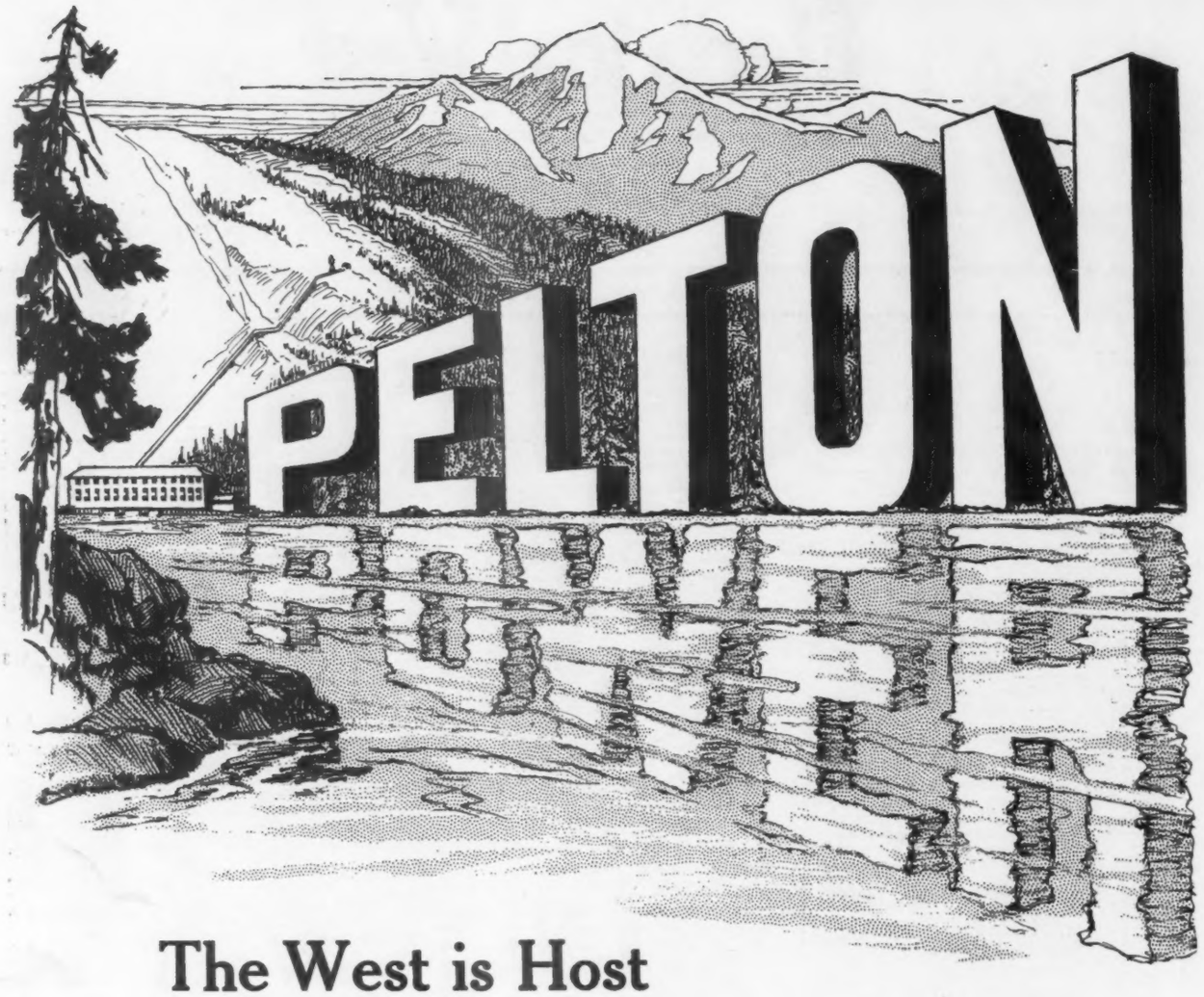

The West is Host to the N. E. L. A.

EASTERN power executives and engineers look upon their annual convention held on the Pacific Coast with more than usual anticipation. Aside from their normal convention business it is their opportunity to see first hand, the high state of development that Western utilities have reached, and particularly the manner in which nature's water resources have been capitalized. It is both a privilege and an opportunity for members of the P.C.E.A. and the N.W.L.&P.A. to extend the hand of fellowship in the arrangement of inspection trips to our outstanding power developments.

As a member of these associations, The Pelton Water Wheel Co. extends its welcome to the delegates and guests attending the 1930 convention of the N.E.L.A. in San Francisco. Our doors will be thrown wide open to those interested in the design and manufacture of hydraulic turbine equipment and accessories. Work of unusual interest will be on view—a ten-minute ride from convention headquarters.

THE PELTON WATER WHEEL COMPANY

Hydraulic Engineers

2985 Nineteenth St., SAN FRANCISCO **33 Rector St., NEW YORK**

Associated Companies: I. P. Morris & De LaVergne, Inc., Philadelphia, Pa.; Dominion Engineering Works, Ltd., Montreal. **Pacific Coast Representative for Larner Engineering Co.,** Philadelphia, Pa.

PELTON

MAY 26 1930

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Electrical West

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A Textbook of Progress

BECAUSE the National Electric Light Association will hold its fifty-third annual convention in San Francisco, there will be no conventions of the Pacific Coast Electrical Association and the Northwest Electric Light and Power Association this year. And because the two geographic divisions of the N.E.L.A. will hold no annual meetings, the reports of the sections and committees, as published in this issue of ELECTRICAL WEST, constitute the sole record of accomplishment for the administrative year 1929-30.

THUS these printed pages of type take on added significance and importance. Herein is presented a symposium of progress of the electrical industry in the Western states. These printed reports embody the findings of eight hundred men, members of committees charged with the study and analysis of the problems of every one of the varied and specialized fields of the light and power industry. They represent final reports of countless committee meetings, conclaves and discussions. In terms of dollars they constitute an incalculable investment in time and effort required for their compilation.

TO endeavor to select the most outstanding reports from among the hundreds presented is impossible. Each report offers the latest and most up-to-date findings on the particular subject it covers. Combined they present a comprehensive picture of development in the industry.

THE fact that there will be no conventions of the two associations whose work these reports represent should not serve as an excuse for neglecting to study them. Because there are no conventions, the reports become doubly important. Published, they themselves are the conventions.

TO the searcher after knowledge, to the man with his eyes on the next rung of the ladder, this issue is commended. In it he will find the accumulated experience of eight hundred of his fellows, freely offered so that he may have a better grasp of his own task, may avoid the mistakes that others have made, may profit by the solutions they have found for their problems. He who uses this material as a guide and reference cannot help but advance in the industry. The final value of the reports rests upon the extent to which they are used.

More Kilowatt-Hours Per Customer

By E. B. Criddle

President, Pacific Coast Electrical Association

THIS means simply a more intensive use of electricity by all users. New uses are constantly being developed, but those who can benefit by electric service are often slow to learn of its advantages. They must be educated; it is our job to do this. All of our companies are working diligently and successfully to build up the domestic load; each year the average kilowatt-hour consumption per residence customer increases — the average for this country for 1929 was 502. There remains, however, a very wide field and it will be long before the average will reach, as it should and will, in excess of 3,000 kilowatt-hours per year.

One of our very important committees is that on the relation of electricity to agriculture. Splendid work is done by this committee in cementing a friendly feeling and a fine working spirit between the utility and the farmer. Here again, intensive salesmanship is needed to induce the farmers to utilize our service fully. They need it, it will save them money, but not five per cent of them are using more than a small fractional part of what they should use.

E. B. Criddle

These are merely typical illustrations of the selling problems yet ahead of us. Our commercial departments need to be very wide awake to carry on intensive selling effort. Competitive power, through the great surplus of natural gas, is a problem to be faced more vigorously than ever before. Our engineers have given this matter very careful study and usually we can show to the prospective customer or to the customer who is listening to the siren song of the salesman for the gas and the engine companies, that theoretical figures can be very misleading. Cultivating the friendship of our clientele, having them know by past experience that our statements are dependable, and that we have their interests at heart, is of the greatest possible help.

Day by day, in co-operative work along these several commercial lines as well as in solving engineering and operating problems, the Pacific Coast Electrical Association, and the National Electric Light Association, the parent association, are demonstrating more fully their great value to the entire industry. The managements of most of the companies realize this, though they sometimes fail to see the importance to the company of Class "B" memberships, or the value of conclave and committee work. If those who work on committees and conclaves will only take home and put to use the things they learn at such meetings, and will let their immediate superiors know about it, the work of the association will be greatly strengthened, and the management will feel more justified in permitting a liberal attendance at such meetings.

There have been many rate reductions in our territory during the year. These are made possible principally by load building — putting the dollars of our investment to fuller use, and partly by the recently accomplished high efficiency of steam plants, and by wide interconnection.

Water shortages of recent years have taught our people the need of steam power of sufficient capacity to meet fully all demands in the dryest years. This has been accomplished by a very heavy building program, and by a more complete interconnection of various systems.

Complete co-operation of the several companies, whether competitive or not, is nowhere more fully practiced than in this territory, again exemplifying the advantages of association contact.

During the past seven and one-half years we have practically doubled in capital invested, in generating capacity, in kilowatt-hour sales, and in revenue. Owing to reductions in rates, revenue has increased less than sales. With $11,000,000,000 invested at the close of 1929, we may expect to double that investment by the close of 1938.

This year, except for a brief session, the P.C.E.A. convention will be merged with that of the national association. To the national association and all of its members we extend a most hearty welcome.

Advertising-Publicity Section[1]

The principal efforts of the Advertising-Publicity Section have been directed toward conducting the eliminations for the national employees' speaking contest in this territory and toward publicity for the N.E.L.A. convention in San Francisco, June 16 to 20.

CONDUCT of the employees' speaking contest was turned over to this Section rather than to the public speaking committee of the Public Relations Section on account of the experience that the Advertising-Publicity Section has had in conducting three-minute speaking contests at the annual Pacific Coast Electrical Association conventions for the last four years. As a matter of fact the Section feels the idea for this years' national contest developed as a result of the work done by the P.C.E.A. in conducting similar contests in years past.

Details of the contest were explained to all employees of the member companies in this territory by means of a four-page pamphlet that was compiled from information furnished by the national public speaking committee.

Briefly, the contest was open to all employees of Class "A" member companies below the rank of department head or division manager. The title assigned to the contests by the national public speaking committee was "The Electric Utility's Contribution to My Community, State and Nation." The delivery of the talk was to take not less than 10 nor more than 15 minutes.

The contests were conducted progressively by the Section in this territory. Elimination contests were conducted by the member companies to select their representative. Semi-finals were then conducted in northern and southern California with five speakers entered in each. Two speakers were selected in each of these semi-finals to compete in finals held in Fresno.

A winner and an alternate were selected at Fresno to compete against representatives of all geographic divisions at the N.E.L.A. convention in June.

As was customary in past speaking contests, the Section arranged suitable prizes for the contest in this territory. The winner in each company contest was awarded a trip to the N.E.L.A. convention with all expenses paid. The winner in the finals was awarded stock in the amount of $100 in any company he chose. The second place contestant received a suitable prize valued at $25.

Interest in the contest was aroused mainly by the prizes offered by the N.E.L.A. The first prize was a trip to Europe with all expenses paid; second prize, $500; third prize, $250.

Two thousand, two hundred copies of the pamphlet describing the contest were distributed to employees of member companies. In addition there was printed a bulletin board card announcing the contest, which was placed on bulletin boards of all district offices, power plants, substations, etc., of the various member companies. The text of this bulletin board card is shown in the accompanying illustration. These were distributed to the number of 650 among the various member companies in this territory. In addition, the section distributed 250 copies of the special booklet describing the contest that was published by the N.E.L.A.

Actual details of the contest in each member company were handled by a special chairman for that company. The chairmen were as follows: W. A. Worthington, Pacific Gas and Electric Company; Al. C. Joy, Great Western Power Company; Lloyd Henley, San Joaquin Light & Power Corporation; O. S. Clifford, Sierra Pacific Power Company; F. S. Thomas, Coast Counties Gas and Electric Company; C. B. Eaton, Southern California Edison Company; Dan L. Scott, Los Angeles Gas and Electric Corporation; Albert Cage, Southern Sierras Power Company; Forrest Raymond, San Diego Consolidated Gas and Electric Company; and A. F. Morairty, Arizona Utilities Association.

Complete records were kept as to the actual number of contestants in each member company, the total number of people comprising the audiences at each contest, and the personnel of the judges at each one of the contests. This report will be turned over to the president of the association for incorporation in this annual report if he so desires. It is anticipated that the winning speech for this territory will be published in Electrical West.

Talk Yourself Into
A TRIP TO EUROPE
That's the FIRST PRIZE in the
N. E. L. A.
Employees' Speaking Contest
Other Prizes Include
1. $500. Cash
2. $250. Cash
3. $100. in Stock
4. A trip to the N. E. L. A. Convention in San Francisco
Ask Your Division Manager or Immediate Superior for a Pamphlet Giving Details of the Contest.
OPEN TO ALL EMPLOYEES
Below the Rank of Division Manager

Fig. 1. Poster announcing employees' speaking contest

[1] George C. Tenney, "Electrical West," chairman. R. G. Kenyon, Southern California Edison Company, vice-chairman.
Arizona Edison company: M. G. Sanders.
Coast Counties Gas & Electric Company: R. G. Barnett.
Central Arizona Light & Power Company: A. F. Morairty.
Edison Electric Appliance Company: P. H. Booth.
"Electrical West": W. A. Cyr.
Great Western Power Company: A. M. Frost, Al C. Joy.
Los Angeles Gas and Electric Corporation: E. P. Ramsay, D. L. Scott.
McGraw-Hill Company: J. W. Otterson.
Pacific Coast Electrical Association: Samuel H. Taylor.
Pacific Gas and Electric Company: J. Chas. Jordan, F. S. Myrtle, James Pollard.
San Diego Consolidated Gas & Electric Company: F. M. Raymond.
San Joaquin Light & Power Corporation: F. C. Foy, S. W. Green.
Southern California Edison Company: W. L. Frost, Fred Garrison, R. E. Smith.
Valley Electrical Supply Company: J. U. Berry.
Westinghouse Electric & Manufacturing Company: E. W. Nilsson.

Commercial Section[1]

GENERAL BUREAU REPORTS[2]

BETTER Home Lighting was the theme of the principal educational activity of the General Bureau during the past year. This, following the precedent of previous years, was expressed by means of an essay contest on the subject, "Better Home Lighting and What I Can Do to Obtain It."

A manual on "Better Home Lighting" was prepared and distributed among the participating utilities. At the date of this report the essays have not been turned over to the essay contest director, but preliminary reports indicate that last year's results will be exceeded.

The judging of essays will be accomplished at Los Angeles on the days of April 10 and 11. Eighty-nine cash prizes, totaling $900 in value, will be awarded to the writers of essays and most of the power companies are awarding additional prizes.

The bureau engaged but lightly in activities of a strictly public relations character. The surplus supply of the educational manual on customer relations, which was used in the first and second essay contests, has been distributed, and a skit has been prepared by R. E. Smith and R. G. Kenyon, both of the Southern California Edison Company, for presentation at the Fresno conclave.

RECOMMENDATIONS

In the development of the load-building educational program of the bureau, we recommended that the bureau next year conduct an essay contest on the subject of domestic appliances.

Of even greater importance, we urge that executives and commercial men in all the power companies exert every possible pressure to educate the department heads in their respective organizations to a realization of the importance of our annual essay contest. We find uniformly that where department heads interest themselves in the contest, the results are gratifying; and that where department heads are indifferent or ineffective, the essay contest is a failure. Inasmuch as our annual essay contest is a load-building effort and has a very definite cash-drawer objective, the reluctance of department heads to enter fully into the project is difficult to understand and impossible to justify.

---

[1] Executive committee—G. T. Bigelow, chairman. E. G. Stahl, vice-chairman. Frank Bevan, G. H. P. Dellman, E. M. Ellis, A. M. Frost, C. E. Houston, J. H. Jamison, A. F. Morairty, Myron McNeal, W. C. McWhinney, J. F. Pollard, R. T. Stephens, G. C. Tenney, R. W. Turnbull, J. W. Wrenn.

[2] C. E. Houston, Southern California Edison Company, chairman.
D. C. Ray, Pacific Gas and Electric Company, vice-chairman.
Coast Counties Gas & Electric Company: O. A. Brugler.
Electrical West: W. A. Cyr.
Great Western Power Company: Howard Jones, J. W. Wrenn.
Los Angeles Gas and Electric Corporation: D. L. Scott.
Pacific Gas and Electric Company: Frank Bevan.
San Diego Consolidated Gas & Electric Company: G. H. P. Dellman, Alfred May, P. P. Pine.
San Joaquin Light & Power Corporation: G. L. Van Buren.
Southern California Edison Company: C. B. Eaton, W. P. Graef, J. L. Kamm, H. C. Rice.
Southern Sierras Power Company: Albert Cage.
Tucson Gas, Electric Light & Power Company: Herbert Painter.

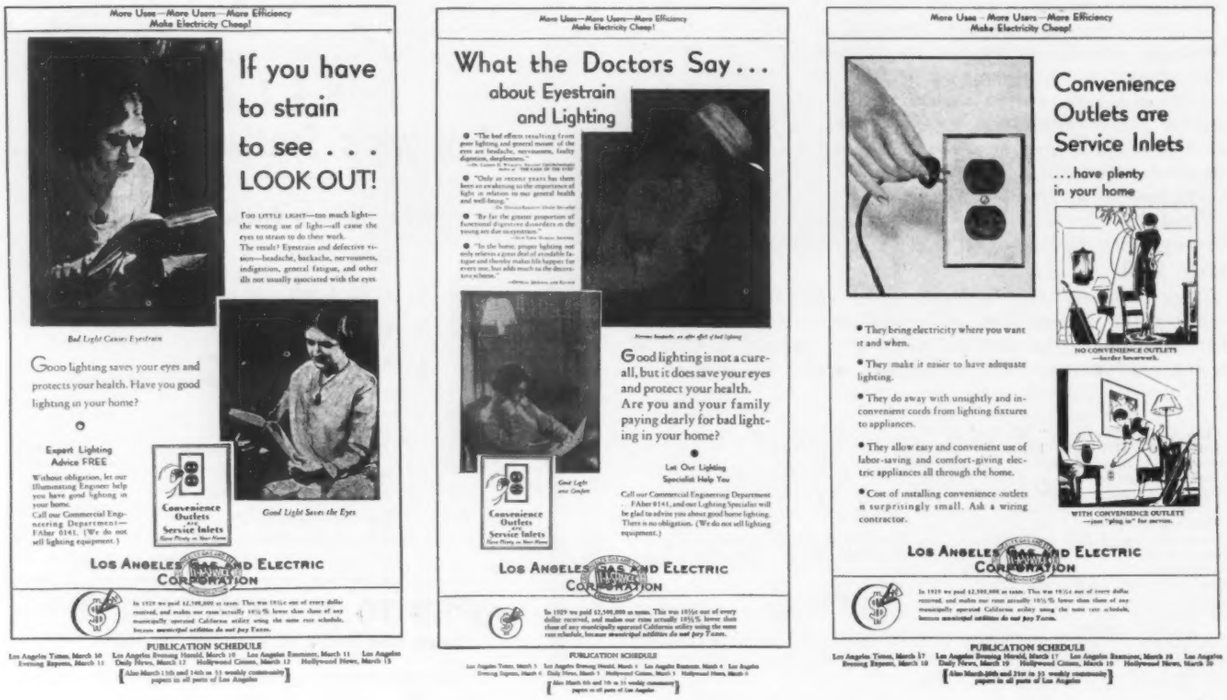
More Uses—More Users—More Efficiency
Make Electricity Cheap!
If you have to strain to see . . . LOOK OUT!
Bad Light Causes Eyestrain
Good lighting saves your eyes and protects your health. Have you good lighting in your home?
Expert Lighting Advice FREE
Convenience Outlets and Service Inlets
Good Light Saves the Eyes
LOS ANGELES GAS AND ELECTRIC CORPORATION
PUBLICATION SCHEDULE
What the Doctors Say... about Eyestrain and Lighting
Good lighting is not a cure-all, but it does save your eyes and protect your health. Are you and your family paying dearly for bad lighting in your home?
Let Our Lighting Specialist Help You
Convenience Outlets and Service Inlets
LOS ANGELES GAS AND ELECTRIC CORPORATION
PUBLICATION SCHEDULE
More Uses—More Users—More Efficiency
Make Electricity Cheap!
Convenience Outlets are Service Inlets
...have plenty in your home
NO CONVENIENCE OUTLETS
WITH CONVENIENCE OUTLETS
• They bring electricity where you want it and when.
• They make it easier to have adequate lighting.
• They do away with unsightly and inconvenient cords from lighting fixtures to appliances.
• They allow easy and convenient use of labor-saving and comfort-giving electric appliances all through the home.
• Cost of installing convenience outlets is surprisingly small. Ask a wiring contractor.
LOS ANGELES GAS AND ELECTRIC CORPORATION
PUBLICATION SCHEDULE

Fig. 1. Samples of advertising used.

LIGHTING BUREAU REPORTS[2]

*Domestic Lighting**

LAST January a joint meeting of the Lighting Bureau and the Advertising Section of the Commercial Section discussed a newspaper advertising campaign on the subject of "Home Lighting." The newspaper portfolio as shown and discussed at this meeting was prepared by Batten, Barton, Durstine and Osborne Advertising Agency of New York for the three Mazda lamp manufacturers. This entire series of ads was prepared under the personal supervision of Bruce Barton.

While this advertising material was prepared in the form of full page newspaper advertisements appearing each week during the year, it was fully appreciated that the electric utilities on the Pacific Coast were not in a position to use this form of copy in its entirety. Nevertheless, the photographic cuts and copy were of such a nature that it was of particular interest to all the commercial organizations.

At the present time, the Lighting Bureau is endeavoring to secure a large number of these copies from New York for general distribution among the member companies of the Pacific Coast Electrical Association. As a result of the discussion at the January conclave, the Los Angeles Gas and Electric Corporation undertook to use some of this newspaper copy in a revised form adapted to their particular territory. Briefly, the set-up is as follows:

The ads will be run one each week for at least thirteen consecutive weeks, the same ad appearing on different days in the large daily newspapers and appearing in each of the weekly papers published at the end of the week.

In addition to this, we are circularizing virtually every contractor, dealer and jobber in the territory supplied by this corporation with a preview of the ad as it is to be published, along with a letter. This mailing list comprises approximately 700 names.

In conclusion, arrangements are being made at the present time to secure photographs in addition to the accompanying copy from New York which will be available to those member companies who are interested.

---

[2] Frank Bevan, Pacific Gas and Electric Company, chairman. G. H. P. Delimann, San Diego Consolidated Gas & Electric Company, vice-chairman.
California Electrical Bureau: V. W. Hartley.
Edison Lamp Works: W. E. Carlson.
National Lamp Works: Clark Baker, Sr.
Pacific Gas and Electric Company: W. P. Bear.
San Diego Consolidated Gas & Electric Company: G. H. P. Dellmann.
San Joaquin Light & Power Corporation: J. E. Hammond.
Sierra Pacific Power Company: O. S. Clifford.

* Report of domestic lighting committee, Lighting Bureau, Commercial Section, W. E. Carlson, chairman.

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*Electrical Advertising**

THE appearance of our streets at night is rapidly changing with the ever-increasing number of Neon gas signs. Whether we like this or not from the angle of type of load makes no difference and if there is a rate problem involved, this committee does not deem it within its jurisdiction to consider that phase. There is, however, a problem in this connection for the commercial men of this industry to solve—and that is to keep this form of advertising useful to our consumer.

As the number of signs grow greater, the individual sign loses in its attraction power because of two things—first, by the similarity to other attractions, and secondly, by the type of light. Both of these problems have the same solution, the augmentation of such signs with incandescent lamp lighting in the form of running borders, sun bursts, etc. This tends to make the sign have a greater pulling power and also softens the Neon lighting, not to a point of detracting from its effectiveness, but making it more pleasing to look at.

Floodlighting is recommended as one of the major lighting load building activities.

Floodlighting has not received the consideration that it deserves because it has been thought of and used primarily for the flooding of light over wide areas and this form of illumination is objectionable to the occupants in many buildings where otherwise the lighting might be of decided advertising value to the building owners. For this class of building, types of floodlighting units have been designed which concentrate the light on certain areas where it is not objectionable, giving very beautiful effects and serving as a very fine advertising medium.

This type of lighting is well illustrated by the lighting of the Richfield Oil building in Los Angeles. Four hundred flood lights are installed thereon, with a load of 150 kw.

The lighting of playing areas for outdoor sports very definitely has an advertising value and adds tremenduously to the period of usefulness and hence the value of the land.

* Report of electrical advertising committee, Lighting Bureau, Commercial Section. G. H. P. Dellman, chairman.

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*Industrial Lighting**

The unusual interest in better lighting aroused by the celebration of Light's Golden Jubilee should be taken advantage of to develop the industrial lighting market. The biggest opportunity lies in the betterment of existing inadequate installations. The committee recommends the adoption of the Franklin Red Seal Certification Plan by member companies. The plan is here outlined and sample letters for its presentation to industrial executives are given.

LAST year, the world celebrated Light's Golden Jubilee, the fiftieth anniversary of the invention of the incandescent lamp. Never before in history did light and its utilization command such wide attention. The story of adequate lighting was given a new impetus. As a result, untold opportunities for the development of the industrial lighting market have been opened up.

A Growing Market

Changing conditions and shifting trends in business and industry are ever bringing new demands for increased illumination, adding to the already vast undeveloped market for more light and for better lighting equipment. In at least 65 per cent of all existing industrial and semi-industrial plants improvements in the lighting system are needed. In a large percentage, the whole system is obsolete, while all of them could improve their lighting in at least part of the plant.

Not more than ten years ago, factory executives looked askance at the suggestion that they would benefit by raising the illumination in their plants to ten foot-candles. Two or

* Report of committee on industrial lighting, Lighting Bureau, Commercial Section. J. E. Hammond, chairman. R. A. Crosby, R. V. Ludlum, C. O. Martin, T. F McDonough, J. O. Presbrey, M. L. Saunders.

three foot-candles was the order of the day and three times as much light seemed a pure waste entirely uncalled for. The new order was accepted by some, however, and it was not long until these executives discovered to their own satisfaction that ample light costs very little in comparison with the many benefits derived. And now some of the largest corporations, on their own initiative, are using as high as 100 foot-candles and more, as a cold dollars-and-cents proposition.

The Big Unsold Market

It is quite evident what these big and rapid advances in lighting standards have done towards rendering obsolete most of the existing plants of the nation. While a few of these plants realize this condition, most of the others must be made to realize the inadequacy of their present installation and must be shown the need for a more modern lighting system.

In his address to the National Survey Conference at Washington on Dec. 5, 1929, President Hoover sounded the keynote for the lighting industry's selling program in 1930. The following paragraph from the President's address has special import.

> The greatest tool which our economic system offers for the establishment of stability is the construction and maintenance work, the improvements and betterments and general clean-up of plants in preparation for cheaper production and the increased demand of the future.

The place that better plant lighting occupies in the above program and its importance to the lighting industry and to the central station, in particular, is at once evident. There are immeasurably greater opportunities in raising standards of lighting in present installations than in the vastly more limited new construction market. By this, it is not to be inferred that new establishments should be neglected and should not be given careful attention to see that they measure up to modern standards with sufficient reserve for future advancement.

The big market, then, and the one awaiting the lighting specialist right here and now, in bad times and in good, is the betterment and replacement of existing inadequate installations.

Need for Organized Market Development

It goes without saying that the electrical industry as a whole is vitally interested, as beneficiaries, in this extensive market. It remains for the lighting industry, however, to educate and to crystallize this potential market into definite results in terms of added kilowatt load and increased lighting equipment sales to meet the customer's needs. Much too little organized selling effort, it is believed, has in the past been directed by the central station to the lucrative lighting market. It has been left pretty much up to the demands of industry itself for higher production efficiencies and the consciousness on the part of factory executives that higher and higher intensities are of a distinct benefit to him.

Plan for Local Market Development

The purpose of this report, therefore, will be to set forth and to outline a plan for local market development and to assemble samples of material which is available to the electric and power companies for the execution of this program.

1. *Adoption of the Franklin Red Seal Plan*[1]—

It is recommended that the member companies adopt and put into operation the Franklin Red Seal Certification plan that has been prepared by the industry under the auspices of the Society for Electrical Development. Details of this plan may be secured directly from the headquarters of the society mentioned above.

2. *Compilation of a List of Qualified Industrial Prospects*—

The basis for any successful market development campaign on industrial lighting is a list of qualified prospects for industrial lighting. Practically every industrial plant is a prospect for better lighting in some part of the plant. New standards of intensities, new and specialized equipment, offer even the industrial plant with an installation only four or five years old an opportunity to improve its plant lighting with advantage.

Industrial prospects should be qualified by excluding those who are definitely known not to be in the market for lighting because they have recently installed an up-to-date lighting system. Plants that are too small in size to justify the expense of the mail and sales follow-up, or that are shut down or in financial difficulty, should also be eliminated.

After completing the selection of industrials to be included in the selling campaign, it must be carefully determined who in the organization will make the buying decision, and the name and title added to the mailing list. This is important later, in the direct mail campaign, for letters addressed to the company, only, may not reach the individual who should be interested, nullifying completely the pre-selling objectives of these letters.

Investigation shows that the following individuals in an industrial organization generally have an important part in making the decision as to better plant lighting:

1. The general superintendent or works manager.
2. The chief electrician or plant engineer.
3. The general manager or vice-president in charge of production.
4. The purchasing agent.
5. The owner (of a small firm).

Where names of industrials are taken from various sources, they should be carefully cross-checked to avoid duplications. All addresses should be verified and made as complete as possible, giving in each case the street number and name.

3. *Mailing the Franklin Lighting Letters to the List of Qualified Prospects*—

A direct mail campaign will arouse the interest of the qualified prospects and break down sales resistance for salesmen. It is recommended that the power company use the Franklin lighting letters that have been prepared by the industrial and commercial lighting committee of the Society for Electrical Development. These four letters accompany this report.

The use of a return post card for the booklet, "Light and Production," which may also be obtained from the Society for Electrical Development, or of a card asking for the call of an engineer or lighting specialist will locate immediate prospects who are at least interested enough to want to know more. A prompt, personal follow-up call while the interest is fresh may subsequently lead to the closing of a definite sale.

The aim of the above mentioned booklet is to make the reader conscious of the inadequacy of his lighting system by pointing out in a simple way the defects present in so many plants. As he goes through his own plant, comparing lighting conditions there with those which the booklet points out as being necessary to obtain maximum operating efficiency, he will begin to realize that he, also, should call in a lighting specialist in order to improve his lighting system.

4. *A Systematic Personal Follow-Up of All Qualified Prospects*—

The highest results will be secured from a direct mail campaign to promote the idea of better lighting if each qualified prospect on the list is followed up personally by the lighting salesman or lighting specialist.

Where the list is very large, it is desirable first to select

those prospects that have made a definite inquiry for the booklet through the return post card. It has been found of advantage to have this booklet delivered in person by the lighting specialist rather than sent through the mail. The reason for this is that it serves as a good excuse to call and make an initial contact. However, many interested prospects may fail to return the post card and it is important for this reason that all qualified prospects on the list be called upon as soon after the mailing as possible.

These follow-up calls should have as their objective:

(*a*) To secure prospect's agreement to give careful consideration to the recommendations of a lighting survey to be made in his plant.

(*b*) To convince prospect of the advantage of better lighting by arranging for test installations in his plant, showing what has been accomplished in other plants, or providing some form of lighting demonstration.

5. *Mobilizing the Interest and Co-operation of All the Electrical Interests—*

The distributors should be asked for their support and co-operation in providing the necessary reflectors for trial installations and in emphasizing to their contractor customers the opportunities in lighting during the period of the market development program.

A letter should be sent to the electrical contractors asking their co-operation in this campaign by talking better lighting to their own customers and by making a systematic effort to secure lighting installation jobs.

A copy of the Franklin specifications should be supplied by the power company to every electrical contractor in the city.

Wherever possible, a school or conference should be organized, consisting of at least two or three meetings for the purpose of making contractors and others thoroughly familiar with the aims and the method of the Franklin Red Seal specifications for adequate lighting. Someone, thoroughly familiar with the specifications and with lighting, should demonstrate the simplicity of these specifications to the contractors through actual problems and solution work at the meetings.

Lamp companies and reflector manufacturers should be invited to participate in such a market development program.

6. *Magazine Lighting Stories—*

It is recommended that lighting stories describing actual installations be written for publication in trade magazines and periodicals.

There are numerous specialized industries which, in themselves, represent large individual groups which maintain associations and publish their own trade periodicals. Fruit canners and packers, printers and lithographers, laundries, lumbermen, oil producers and oil merchandisers are examples of these groups of industries, each one of which has its own peculiar lighting problems. Once these problems have been solved and a typical plant has been adequately lighted, a story with photographs describing the installation would be of immeasurable interest and value to the other members of the same industry and would be welcomed for publication.

An example of the far-reaching results of this method of market development might be cited in the case of one of our member central stations in Southern California, whose lighting specialists, in co-operation with the electrical department of one of the large oil companies, laid out and had installed an improved system for the lighting of an oil well drilling rig. Data and "before and after" photographs together with a story were published in one of the petroleum magazines, and, to date, inquiries have been inspired from as far back as the Oklahoma oil fields.

7. *Compilation of Book of Photographs—*

It has been found that every good lighting installation sold in a community helps to sell others and, where full advantage is taken of this fact, the lighting business may be made to grow much like a rolling snowball.

A most effective way of capitalizing on this fact is the compilation of a book of photographs of the better industrial lighting jobs, each accompanied, where possible, by a testimonial letter from the customer regarding the benefits derived and, of course, full data on the installation. Photographs, taken before the relighting was done, add force and value to this work.

It is recommended that the central station lighting service department systematically set about preparing such a book for the use of all its lighting salesmen and lighting specialists, who should also be enlisted in the accumulation of the material for the book.

Conclusion

The foregoing recommendations have been presented as some of the things easy of attainment by the central station in its quest for avenues to new business. Further forms of action will suggest themselves and should be taken to develop and to realize the opportunities, both present and future, in the industrial lighting field.

It has been pointed out that the big industrial lighting market lies in existing plants, already served by the power company. In most cases, the present transformer and feeder facilities of these establishments are capable of carrying the required added load, which make for economy in acquiring this new business.

It goes without saying that the responsibility for this phase of the central station's business must be vested in a department which gives its undivided attention to lighting. No central station, therefore, is taking full advantage of its opportunities unless it supports a lighting service department.

Appendix I—Letters to Sell Productive Lighting to Factories[3]

Each of the four factory letters has for its purpose:

1. Carrying an educational message to the potential buyers of factory lighting, with the simple facts concerning good lighting as it bears on their business.

2. Opening the way for the company's or league's lighting representative prior to his call. Sending of the letters prepares the way and frequently relieves the salesman from going through a process of educating the prospect in the simple facts about lighting which can be accomplished usually much more cheaply and with better effect through illustration and the printed word.

3. Selecting the likely interested prospects from the numbers of firms in a group which are deemed in need of improving their lighting. The return inquiry cards indicate those whose interest in the subject of lighting would justify a call.

Send to Architects and Builders

All of the letters are especially suited for sending to the architects and builders in the territory. There should be discrimination, as architects who specialize on homes and do not engage in industrial work will not be interested in the industrial series.

Complete, Ready to Use

A complete letter, ready for multigraphing, has been prepared for the first page of each Franklin lighting letter and appears on the four specimen letters which follow.

This first-page copy ties in, in each case, with the printed text on the inner pages of the Franklin lighting letters. This

[3] Material mentioned in this report may be secured from The Society for Electrical Development, 420 Lexington Avenue, New York, N. Y. Prices: Franklin Lighting Letters, $11.50 per hundred; Franklin Specification, 15 cents per copy; Light and Production, no charge.

copy in most cases, has been written to lead the reader to turn first to the two inner pages and then to read the "action" paragraph in the first-page message.

Where Franklin Red Seal Plan is Operated Locally

Where the league or power company operates the Franklin Red Seal Plan, the service based on the Franklin specification and Franklin Red Seal inspection and certification should be brought out and stressed in the first-page letter.

Treatment of Fourth Page

Optional methods for the use of this page are outlined in the booklet which accompanies the letters.

Typical Return Cards

Several return cards are suggested which have proved effective in drawing inquiries and arousing interest. The recently introduced form of collect return postcard requiring no affixing of stamp by the sender is preferable.

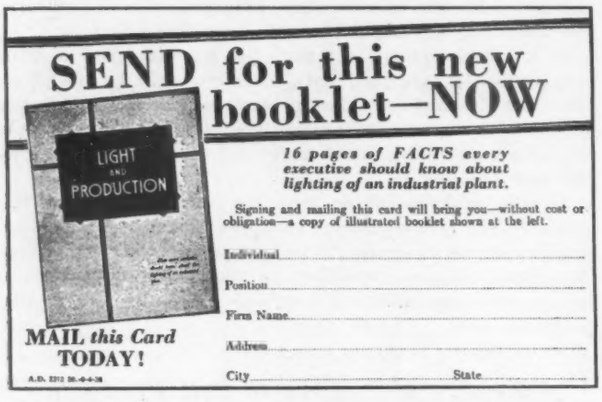
SEND for this new booklet—NOW
LIGHT AND PRODUCTION
16 pages of FACTS every executive should know about lighting of an industrial plant.
Signing and mailing this card will bring you—without cost or obligation—a copy of illustrated booklet shown at the left.
Individual
Position
Firm Name
Address
City
State
MAIL this Card TODAY!

Fig. 1. Sample of return postcard which has proved effective.

Alternative Copy for First Page

Personal experience, preference or special local conditions may make another type for variation of first-page letter preferable. Therefore, alternative copy is included. These alternative letters have been collected from lighting service companies. Included are those which their originators have found most productive of inquiries and stimulation of interest. From these a number have been chosen exemplifying diversity of treatment and ideas.

To Whom Should Letters be Sent

The number of individuals in a given company who should receive the letters will depend obviously on the size of the company. A one-man enterprise will call for mailing to only one individual in the company. On the other hand, in the case of large industrial plants, the general manager, production manager, plant engineer (or maintenance or electrical engineer) should each receive the letters, preferably simultaneously. In some cases it has been found worth while to include the president and a financial executive.

Personal Solicitation Essential

It is generally recognized that direct mail letters are not sufficient in themselves to consummate sales. In this field of lighting, they are effective and useful only to the degree they are coupled with personal selling effort. It is of the utmost importance that no more letters be sent out than can be followed up promptly by the calls of lighting representatives. There should be no lag between the receipt of an inquiry card, betokening interest, and a call by a representative. This leads us to the conclusion that good results are secured only where letters are not mailed in gun-shot fashion.

This is particularly true of selling lighting in the factory field, where the interest of busy, preoccupied executives is difficult to secure, and prompt action must immediately follow any evidence of interest growing out of the sending of the letters.

Assistance in Special Cases

The Society, on request, will assist quantity users of Franklin lighting letters in wording their first-page copy where unusual local conditions require it.

Samples of Letters Used

CENTRAL POWER COMPANY

ANYWHERE, U. S. A.

.....19

Mr. S. M. Peters, General Manager,
Crown Manufacturing Company,
220 Front Street,
Anywhere, U. S. A.
Dear Sir:

"A Thousand Thieves
Within the Gates"—

This is not a story of Ali Babba and the Forty Thieves—it's the story of a modern factory and ten thousand thieves.

Forty thieves are plenty, anywhere, at any time, but they are bush leaguers compared to the thieves which are despoiling otherwise modern factories.

The worst of it is that these thieves are easy to detect. Please turn the page and read the parable.

That leaves only one thing to do—put us on the trail of your production leaks, and let us trace these thieves—without obligation to you.

Very truly yours,
District Manager.

CENTRAL POWER COMPANY

ANYWHERE, U. S. A.

.....19

Mr. S. M. Peters, General Manager,
Crown Manufacturing Company,
220 Front Street,
Anywhere, U. S. A.
Dear Sir:

"Production increased 2/5ths"

Please read the inside of this letter first—yes, right now if you will be so good. Over—turn the page—thank you!

Now that you have read the inside message, and gained the broad facts regarding modern factory lighting, we have a proposition to offer you.

It is this:—Without any obligation to you we will show you what the national standards for good lighting in your business are; then we will measure your own lighting and show you how it compares with these standards; finally, if your lighting falls short of the accepted practice, either in quantity or in quality, we will show you how to bring it up to requirements most economically.

This is an important matter to you, for if your lighting is below your industry's standard, you are suffering a production handicap as compared to your competitors.

Please telephone, and let us know what time would be most convenient for our lighting service man to call.

Very truly yours,
District Manager.

CENTRAL POWER COMPANY

ANYWHERE, U. S. A.

.....19

Mr. S. M. Peters, General Manager,
Crown Manufacturing Company,
220 Front Street,
Anywhere, U. S. A.

Dear Sir:

"Is the *Game Called—on account of darkness*

in your factory?"

Please turn the page—and read the message you'll find there—and then turn back to this. Thank you!

All that we have to add is that we know our business when it comes to designing and installing lighting. Lighting is probably one of the few things in your business which we know more about than you do. If you are willing to grant us this, we are sure it will be to your advantage to let us call and make a survey of your lighting. There will be no obligation—but you may find that we can do you a real service.

Very truly yours,

District Manager.

CENTRAL POWER COMPANY

ANYWHERE, U. S. A.

.....19

Mr. S. M. Peters, General Manager,
Crown Manufacturing Company,
220 Front Street,
Anywhere, U. S. A.

Dear Sir:

"Glare kills eyes and kills Profits"

To get a rough idea of whether you need better lighting or not don't look *up* at the lights—they may be *too* bright! Look *down* at the work instead.

If you will turn the page and read the illustrated message there, you will understand why we would appreciate the opportunity of making a lighting survey in your plant—without obligation to you.

We are selfishly unselfish in this offer. For if you do need better lighting, you will profit from it hundreds of times more than the amount of our profit in revising your present system.

Please turn the page—and bear in mind that we are at your service.

Very truly yours,

District Manager.

Suggestions for the Last Page of Letters to Factories

Experience in selling with direct mail indicates that it is best to avoid crowding text and illustrations all over the page. Many otherwise good letters go unread direct to the waste basket because a crowded effect as a rule does not invite the busy man to read.

The central idea of the Franklin lighting letters is distinctiveness achieved through simplicity in arrangement and the very minimum of text matter, in contrast with the letters most frequently seen which are overloaded with ideas, slogans, inserts, etc. Many users favor leaving the back page entirely blank, as it sets off the personal message on the front page and the simple treatment on the inner pages.

For those who desire to carry something on the last page, the following suggestions have been prepared. If used at all, it is believed the best results will be achieved where the text, illustration or emblem on this page is very concise, such as may be read on the run, and confined to a block effect in the center, with two or three inches of white margin all around it.

Optional Treatment for Last Page—

1. Where the league or power company is operating the Franklin Red Seal Plan, print a concise statement describing the advisory and layout service it offers without charge or obligation, based on the Franklin specification and including Franklin Red Seal inspection and certification. This statement should be confined to 50 or 60 words and appear in bold type in a box.
2. Reproduce the Franklin Red Seal emblem or that of the league or power company, with a brief explanatory caption in italics beneath it.
3. Four or five line statement (in bold-face type) about the league's or power company's corps of lighting specialists and lighting consultation service, available without charge or obligation.
4. Reproduce photo of model local factory lighting installation with two-line caption giving particulars and names. A suitable caption or a two-line testimonial give point to the benefits which are enjoyed by the owner or company.
5. Quote a pertinent excerpt from a commendatory letter received from a satisfied user of an installation laid out by the league or power company.
6. Show illustration of typical lighting recommendation in report form, as prepared by league or lighting service department for a factory executive. There should be a two-line caption to epitomize the company's or league's engineering resources available to officials or executives without cost.

Alternative Copy for First Page of Franklin Lighting Letters to Factories

CENTRAL POWER COMPANY

ANYWHERE, U. S. A.

.....19

Mr. S. M. Peters, General Manager,
Crown Manufacturing Company,
220 Front Street,
Anywhere, U. S. A.

Dear Sir:

A lighting survey of approximately 300 industrial plants revealed that 15 per cent of them were well lighted, 29 per cent were fairly well lighted, and 56 per cent were poorly lighted.

The plants classed as poorly lighted were also noted to be relatively less efficient—employees were working under a handicap, production was lower and spoilage higher.

Don't let your plant be inefficient because of its lighting. It is easy to have good lighting.

This company maintains a staff of engineers who plan correct lighting layouts and advise on all lighting problems. Phone us today—Main 4600, extension 12—and let us show you where good lighting will pay big dividends on the outlay in speedier production and better quality of product.

Very truly yours,

District Manager.

CENTRAL POWER COMPANY

ANYWHERE, U. S. A.

.....19

Mr. S. M. Peters, General Manager,
Crown Manufacturing Company,
220 Front Street,
Anywhere, U. S. A.

Dear Sir:

The manufacturer who can build his product for the least money is the one who now secures the orders and makes money.

Cutting production costs to meet the keenest competition we have known in years, is paramount in most of America's factories. Everything possible is being done to clip the pennies off unit costs.

Right lighting is an important means to that end. Right lighting is now considered by leading executives to be as vital to efficient, low-cost production as are tools, standardization or labor.

You can get the proof of this at first hand right here in Anywhere and vicinity. We can take you to several large and small plants and show you the kind of lighting we are prepared to lay out for you. Then, if you want to talk to the management of those plants, you can get their story on the economies obtained.

May we not go further into this with you?

Set a time to suit your convenience and our Lighting Engineer will be on hand with all the facts. Just put your name on the enclosed card and the time you will receive our Engineer, and put it in the mail basket, *NOW!*

Very truly yours,

District Manager.

CENTRAL POWER COMPANY

ANYWHERE, U. S. A.

.....19

Mr. S. M. Peters, General Manager,
Crown Manufacturing Company,
220 Front Street,
Anywhere, U. S. A.

Dear Sir:

You wouldn't be satisfied today with the quality of product your plant produced ten years ago.

Nor would you be willing to use the same mechanical equipment. For manufacturing standards have changed from those of yesterday.

Lighting standards, too, have changed. The lighting system that was considered the last word in illuminating efficiency ten years ago is likely to be inadequate for today's more exacting requirements.

In your plant, there is only one way to make sure that the lighting will keep down production costs, spoilage and accidents. That is to have it inspected and measured by a lighting specialist. He can quickly tell you whether your lighting is helping or hindering efficient factory operation.

On the inside pages, you'll find interesting facts on what better lighting can do for you. Read them, then get in touch with us. Send the enclosed card today and tell us when you would like our Lighting Engineer to call.

Very truly yours,

District Manager.

CENTRAL POWER COMPANY

ANYWHERE, U. S. A.

.....19

Mr. S. M. Peters, General Manager,
Crown Manufacturing Company,
220 Front Street,
Anywhere, U. S. A.

Dear Sir:

Does it surprise you to be told—

—that improved lighting enabled the Timken Roller Bearing Company engineers to get 12½ per cent increase in production in the inspection department, equal to five times the cost of better lighting?

That the Shelby Salesbook Company has been able, through a change in lighting, to make production during artifically lighted hours equal to that of the brightest daylight hours?

That the Dover Manufacturing Company has achieved an increase in production of 12.2 per cent in its press department, through better lighting, at an increased cost of only 2½ per cent of the payroll?

That modern lighting in the Rich-Sampliner Knitting Mills, (Cleveland, Ohio,) has accomplished a 15 per cent increase in production with a 10 per cent decrease in accidents?

Let us be *your* lighting counsellors.

We have no desire to do anything revolutionary with your factory lighting—that is not the way we work. But we would like to make recommendations to you as regards what modern lighting will do to aid you in securing the best results from the Electric Service we supply.

Just fill out the enclosed card or 'phone us, Main 4600, extension 12.

Very truly yours,

District Manager.

CENTRAL POWER COMPANY

ANYWHERE, U. S. A.

.....19

Mr. S. M. Peters, General Manager,
Crown Manufacturing Company,
220 Front Street,
Anywhere, U. S. A.

Dear Sir:

Much progress in recent years has been made in the art of good lighting. Lighting methods and equipment that were necessary in the days of inefficient lamps are now obsolete; today, they exert a hardship on the plants that continue to retain them.

Good lighting increases production, decreases accidents, and improves the sanitation and morale of the factory. These facts have been proved by conclusive tests made in plants similar to yours throughout the country.

This company has a number of Lighting Experts who will be glad to study your plant, and without interrupting or disturbing anyone, make a survey of the effectiveness of your present lighting installation. A complete report will be furnished as to just what changes should be made, if any, to make your lighting as useful and productive as it should be. The report will be definite and specific, based on your factory and no other; it will be accompanied by actual working blue-prints which your contractor or electrician can easily follow.

There is, of course, no charge or obligation of any kind for the services of our Lighting Engineer, nor for his complete report or drawings.

A post card is enclosed which we ask you to sign and return to us. Please indicate in the space provided the time for him to call that would be most convenient for you. We believe you will find his call genuinely profitable.

Very truly yours,

District Manager.

CENTRAL POWER COMPANY

ANYWHERE, U. S. A.

.....19

Mr. S. M. Peters, General Manager,
Crown Manufacturing Company,
220 Front Street,
Anywhere, U. S. A.

Dear Sir:

In a letter, Secretary James J. Davis, of the U. S. Department of Labor, said:

> "A well-lighted institution is generally a prosperous institution. A poorly lighted, dingy factory does not inspire the workman to do his best, neither does it tend towards satisfactory production.
>
> "I would go so far as to say that in manufacturing establishments, in which the very best lighting facilities are lacking, not only will the best efforts of the managers and workers be affected but the stockholders will not entirely escape the distress when they receive their dividends."

Man is a daylight animal. When you put your workmen at a machine or bench with illumination of less than one-fiftieth of one per cent daylight power, is it any wonder that material spoilage becomes a sizable factor in your expenses, accidents to men

or machinery are of daily occurrence, and production records are much below where they should be?

Our lighting engineer will gladly prepare for you a Franklin Specification report of what your plant needs to give you a lighting installation which will make it easier for your workmen to attain the lower production costs you desire.

We shall be glad of the opportunity to furnish this survey without obligation. Mail the return postcard and our lighting engineer will be placed at your service without cost or obligation.

Very truly yours,

CENTRAL POWER COMPANY.
By

CENTRAL POWER COMPANY

ANYWHERE, U. S. A.

.....19

Mr. S. M. Peters, General Manager,
Crown Manufacturing Company,
220 Front Street,
Anywhere, U. S. A.

Dear Sir:

"Step on the gas."

That's the common expression when you want more miles per hour.

In industry the expression is, "Step up the light" if you want more output and lower costs from a given number of workers and machines. Light is to industrial production what gasoline is to a motor.

The kind of lighting you are using in your plant may be keeping up costs. If your lighting system has not been revised within the past five years, your plant is likely to be improperly lighted according to today's standards. Meanwhile, you may be putting up with higher production costs and spoilage that could be avoided.

Our lighting specialists are qualified to tell you whether your lighting is helping or hindering your plant efficiency. The services of these specialists are without charge and entail no obligation.

Telephone or send us the enclosed card today. We shall be glad to send a lighting specialist to counsel with you on your lighting problems.

Very truly yours,

District Manager.

CENTRAL POWER COMPANY

ANYWHERE, U. S. A.

.....19

Mr. S. M. Peters, General Manager,
Crown Manufacturing Company,
220 Front Street,
Any City, U. S. A.

Dear Sir:

When daylight fails—as the approaching days grow shorter with shrinking daylight working hours . . . .

Will production in your plant slow up—will spoilage increase and will the number of accidents to men and machinery start upward—all because of insufficient or improperly laid out plant lighting?

The following and many other examples point to correct plant lighting as an aid to production. In the United States Post Office there was an increase in the quantity of mail handled of 13 per cent when the illumination was increased from 3.3 units of light to 7.5 units of light. A dry-goods manufacturer with improved lighting recorded a production increase of 24 per cent.

And correct lighting in your plant will help you reduce your share of the millions of dollars lost yearly through accidents to men and machinery. Only recently the Babson Statistical Organization stated in a current bulletin that a careful survey conducted by them showed between 15 per cent and 20 per cent of all the industrial accidents in the United States are caused by poor light.

We would like to show you how much to your advantage it would be to bring your lighting equipment up to the standard of the Franklin Specification.

May we send you our lighting engineer whose services are supplied without charge or obligation? Please note in the space provided when it will be convenient for you to have him call. Or, phone Main 4600, extension 12.

Very truly yours,

CENTRAL POWER COMPANY.
By

CENTRAL POWER COMPANY

ANYWHERE, U. S. A.

.....19

Mr. S. M. Peters, General Manager,
Crown Manufacturing Company,
220 Front Street,
Any City, U. S. A.

Dear Sir:

A presumably well-lighted factory recently conducted a careful check of its plant lighting. Following the check, alterations were made to conform to modern standards of lamp location, distribution, glare reduction, etc. After a test period, production records showed the following results due entirely to the improvement in plant illumination:

18 per cent more production
23 per cent less spoilage
26 per cent fewer accidents

The cost of the illumination was less than two per cent of the payroll!

These results are not exceptional. They conform closely to the averages obtained by the introduction of *planned* illumination in hundreds of plants.

Unless you have carefully checked the lighting of your plant recently, you are probably paying an hourly toll to spoilage and higher production costs. Our lighting engineers will gladly confer with you and help work out an economical system of *planned* lighting.

Just fill out the enclosed card or 'phone us, Main 8759, extension 12.

Very truly yours,

CENTRAL POWER COMPANY.
Manager.

CENTRAL POWER COMPANY

ANYWHERE, U. S. A.

.....19

Mr. S. M. Peters, General Manager,
Crown Manufacturing Company,
220 Front Street,
Any City, U. S. A.

Dear Sir:

If a man comes to you with a sound proposition for making money you will at least take a moment to consider it.

The benefits of good lighting, when known, speak for themselves. You don't have to be "sold" through conversation; facts are more convincing than sales arguments. We are confident that any moments you take in considering these facts will be well spent.

The cost of a good installation is small. It seldom amounts to two per cent of one year's payroll. Many tests have shown conclusively that good lighting increases production from 10 per cent to 25 per cent. Certainly few other sound investments offer such a good return.

An adequate lighting installation to conform with the Franklin Specification is a sure investment. We are ready to help you profit by the advantages it offers you.

The return postal will place at your service our lighting engineer without obligation of any sort.

Very truly yours,

CENTRAL POWER COMPANY.
By

MERCHANDISING BUREAU REPORTS[2]

*Successful Campaign Methods**

The answer to "What Makes a Campaign Successful?" can be approximated only after a thorough study of many campaign reports and sales department organizations.

The committee requested campaign reports from member companies but lack of time limited the number received. A well thought-out plan, carefully talked over and ironed into shape before the actual campaign, is obviously necessary for success. Of more importance, is the "getting over" of this plan in its every detail to the company organization and, of course, the most important is acquainting the public with the sale in such a manner that the desired results will be obtained.

For the purpose of this report, we have divided the campaign procedure into seven steps:

I. Sales budget for year.
II. Conference of sales executives.
III. Make it the talk of the company.
IV. Make it the talk of the town.
V. Complete coverage by salesmen.
VI. Keep up interest.
VII. Whoopee ending.

DURING the month of December sales budgets for the year should be made, giving the plan of all major and minor activities and the quota by sales districts of each appliance.

The Complete Year's Activity Outline

The advantage of such a plan is that the campaign of the greatest load building result and sales appeal can be placed in its proper month. It is possible, however, that a load building appliance may be placed in a month other than the month of greatest appeal. For instance, it is the desire of power companies to promote the "year round refrigeration" idea. The month of February, therefore, serves as a good campaign month for such an appliance and also engenders the desire for this appliance in the minds of the public early in the year, with the result that it aids the sale later on during the warmer months.

Either major or minor activity is carried on each month in the load building appliances such as ranges, water heaters and refrigerators, Such a plan serves to stimulate both the sales organization and the public desire to an extent that it favorably affects the sales for the few months following the major activity campaign. Some companies have two major activities each month, one which is sold by the salesmen in the field (generally major appliances), and the other sold over the counter (small appliances).

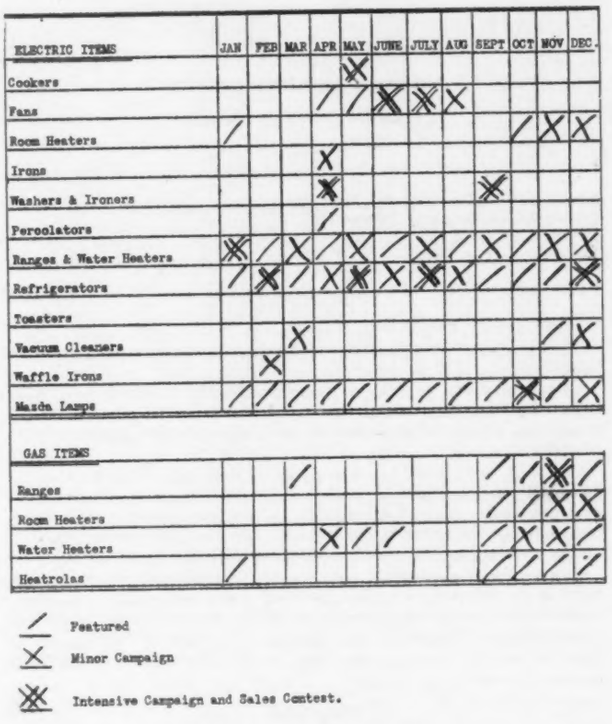

Fig. 1. Typical sales program.

Companies employing the double territory representative plan (one group of salesmen for ranges, refrigerators and water heaters and one group for washers, ironers and vacuum cleaners) may have two major and a minor activity during the month. However, the recommended plan is to have one major and two minor activities each month.

With such a sales budget arranged during the first part of December, the sales department executives can then give their attention in advance to each monthly campaign.

Conferences of Sales Executives to Plan Details of Each Individual Campaign

Conferences of sales executives should be held at least a month previous to each campaign. At the first conference of the commercial manager, merchandise manager and promotion manager the following should be given consideration:

1. Sales appeal, such as prices, special model, small down payment, extended terms, premiums, etc.

2. Advertising motto of campaign. This motto should be carried out in all advertising.

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[2] Myron McNeal, Southern California Edison Company, chairman.
H. H. Courtright, Valley Electrical Supply Company, vice-chairman.
Barker Bros: E. A. Norton.
Belsey Company: George G. Little.
California Electrical Bureau: G. M. Rankin.
Central Arizona Light & Power Company: R. A. Best, R. H. Bradford, A. F. Morairty.
Coast Counties Gas & Electric Company: Pierre Vinet.
Edison General Electric Appliance Company: P. H. Booth, J. P. Bowden, H. F. Huggins, R. H. Robinson, R. W. Turnbull.
Electrical World: W. C. Heston.
Fobes Supply Company: R. F. McDonald.
Gough, Inc., P. H.: Elbert Kramer, C. E. Louis.
Graybar Electric Company: R. W. Kimberlin.
Great Western Power Company: O. F. Anderson, O. R. Doerr, Monty Pfyl, J. W. Wrenn.
Holmes & Sanborn: C. A. Sanborn.
Hoffman Specialty Company: H. H. Daley.
Los Angeles Bureau of Power & Light: A. W. Elliott.
Majestic Electric Appliance Company: M. K. Murphy.
Pacific Gas and Electric Company: W. R. Bowler, L. J. Brundige, E. F. Perkins, J. S. Ross, R. T. Stevens.
Pacific States Electric Company: A. W. Krueger, F. A. Mulvaney.
San Diego Consolidated Gas & Electric Corporation: E. W. Meise, P. P. Pine.
San Joaquin Light & Power Corporation: C. E. Zelhart.
Sierra Pacific Power Company: O. S. Clifford.
Southern California Edison Company: A. W. Althouse, R. A. Bacon, C. H. Calef, H. H. Douglass, H. J. Drexel, W. C. Greene, C. M. Hess, J. C. Hoyt, R. G. Kenyon, Myron McNeal, J. H. Mead, E. D. Minnick, P. V. Moffatt, J. R. White.
Southern Sierras Power Company: W. S. Fleming.
Vallejo Electric Light & Power Company: R. C. Bragg.
Wesix, Inc.: C. B. Merrick, C. A. Russell.
Westinghouse Electric & Manufacturing Company: John A. Clark, H. L. Garbutt, J. H. Jamison, C. H. Paulin.

* Prepared by A. F. Morairty for appliance committee, Merchandising Bureau, Commercial Section.

There is always temptation to adopt the sales plan of some sales manufacturer in its entirety without giving it sufficient thought. Even though a manufacturer's campaign plan is decided upon, every step should be thought out—that is to say, "see how it fits in with the local situation." If possible local color should be added to it. In doing this you at least sell yourself the method of the campaign and then you are in a position to sell the employees and the public. Manufacturers complain of the waste of their campaign material and it is often due to the fact that their campaign plans have been accepted without due consideration as to their application. Human effort only can put over a campaign and while printed plans and advertising will assist, they will not succeed in their silent form.

3. Advertising bogie set.
4. Increase of bogie over that shown in yearly sales budget.
5. Complete written procedure of all steps of campaign.

Make it the Talk of the Company

The entire employee organization should be sold to the point of enthusiasm immediately preceding a sale. It is much easier to enthuse members of the sales department than the employees of the other departments. Prospect commissions will to a certain extent arouse interest among other employees. Letters to all employees informing them of the features of the sale can be used. A new sales manager of an electric company was pondering how to put life into his sales organization when he noted that a great many of the employees of the company reminded him that the company was selling a wonderful electric range of highest quality. One Monday morning throughout the town appeared the words "ask the electric man." Necessarily by noon a great deal of curiosity in both the minds of the public and the employees had been aroused. Just before going to work at 1:00 o'clock there were arranged short talks before the employee groups announcing the sale of electric ranges and explaining the reason for the motto "ask the electric man."

Now.
All Your Friends Can Enjoy
the advantages of
GENERAL ELECTRIC
Refrigeration
without waiting until summer
$5.00 Down
First payment not due for 60 days
22 additional months to pay balance
YES IT'S TRUE . . . WE ARE OFFERING GENERAL ELECTRIC REFRIGERATORS DURING THE MONTH OF FEBRUARY ONLY AT THESE UNUSUAL SPECIAL TERMS ! !
There is no longer any good reason why your friends should not buy their refrigerator now, as these extraordinary and most liberal terms place this electric refrigerator easily within the buying power of every family in this town.
It is expected that this will be one of the biggest refrigerator months that we have ever had. Scores of people who are waiting for the hot weather will buy this month. It is your opportunity to "cash in" on this campaign.
START RIGHT NOW! $1.00 IN ADDITION TO REGULAR PROSPECT COMMISSION WILL BE PAID ON EVERY PROSPECT YOU TURN IN THAT RESULTS IN A SALE THIS MONTH.
Tell all your friends they
can enjoy it now
CENTRAL ARIZONA LIGHT & POWER CO.
SALES DEPARTMENT

Fig. 2. Sample of successful advertising.

The new sales manager felt that it must be a wonderful range since all of the employees of this company were so enthused over its success. The motto attracted the attention of the public to the confidence of the employees in the range they were selling. It goes without saying that the campaign was a huge success because the employees felt that the new sales manager had faith in their judgment. This is an example of arousing the interest of the employees in the sales campaign.

Sales talks giving the details of the campaign should be made at all employee meetings previous to the campaign with an explanation of the prospect commissions allowed the employees for turning in the names of their friends to whom an application is sold.

During a recent campaign which sold 240 electric refrigerators, 400 prospect cards were turned in by the employees. Announcements of the prospect commissions earned by the various employees should be read at the employees' meetings, and the checks should then be presented. Special mention should be made of the employee who earned the largest amount in prospect commission.

Have the management show its interest in the campaigns either by letters from the general manager or by offering a general manager prize.

Previous to the campaign, sales department meetings should be held, when complete details of terms and conditions of the sales should be explained to all salesmen. The promotion manager should present copy of advertisements to be used and should explain all promotional plans.

In addition to the regular commission paid the salesmen, bonuses and prizes should be given the most successful salesman and a booby prize to the lowest. In order to compete for the prizes, make it necessary for each salesman to sell a certain number of appliances. Change the prizes from month to month and contrive to make them of human interest and if possible instill a little humor into the contest. For instance, two leading salesmen of a company worked unceasingly to capture first prize each month until it became the talk of the company. Announcement was made that the second prize was a secret and of such a nature that it would aid the salesman receiving it to go faster, cover more territory and sell more the next month. When the prize was awarded at an employee meeting it was found to be an old broken down bicycle. The humor of this instilled life into the next campaign.

Do Not Mail Campaign Plans to Districts

The merchandise manager and the promotional manager should attend these meetings in person if possible and explain the details of the campaign and also exhibit copies of all advertising to be used. A meeting should be called by each district manager of all employees as well as the salesmen of that district. This meeting should be enthused by some one who has attended the sales meeting at the general office.

Make it the Talk of the Town

With the plan of a campaign arranged and the employees informed it then becomes the job of the promotional manager "to tell the public" in such a way that sales will result. It is difficult to say just how this should be done in each case as local conditions vary, but it is certain if it were possible within the limits of the advertising allowance to inform every citizen of the community about the campaign, maximum sales would result. Generally speaking, therefore, a certain amount of advertising allowance should be spent for mass advertising such as newspapers, radio announcements, dodgers, truck banners, etc. Some companies direct a great deal of their literature to prospects only. (In general the company that does the best job of mass advertising obtains the greatest results.)

A distinctive type of advertising assists the company in the job of mass advertising, especially in the newspaper, where it is in competition with all the other advertisements. The customer may note a distinctive design flash before him

Fig. 3. Floor display of appliances during a campaign

at a picture show and again on a truck banner and possibly again in the newspaper. Repetition of this same design on a dodger when received by direct mail arouses the curiosity of the customer to the point of inquiring as to what it is all about.

It is much more difficult to make your sale the talk of the town in a large city than it is in a small town. Generally speaking the smallest city with a daily newspaper of average circulation has the advantage in matter of publicity.

The proportion of advertising allowance to be expended for advertising depends on local conditions.

The best form of advertising is to enthuse the entire employees' organization. To this can be added other well known forms of publicity, such as teaser advertising, newspaper advertising, dodgers, envelope stuffers, printing on back of company envelopes, window trims, truck banners, picture show slides, store displays, radio announcements, store banners, letters to prospects, soliciting old customers for new prospects, demonstrations at fairs, cooking schools, etc

An example of a distinctive form of advertising is given in Fig. 2.

Complete Coverage by Salesmen

Some form of complete coverage of the territory must be decided upon. Some companies have a territory salesman plan which accomplishes this purpose and also eliminates duplicate effort. A few companies have adopted the double territory salesman plan, one group selling ranges, refrigerators and water heaters, and the other group selling washers, ironers and vacuum cleaners. This latter plan makes possible the concentration of effort on the load building appliances and also solves the problem of selling the washers and vacuum cleaners without using high pressure methods. These two groups also co-operate with each other in obtaining prospects. It is possible for a company using the double salesman plan to alternate their campaigns between the two groups each month. If one of the above plans of coverage is not used it is necessary to supervise carefully the efforts of your salesmen so that the entire territory is solicited.

Keep up Interest

Reports containing "live copy" should be made of the progress of campaigns and a copy distributed to every salesman. Quite often a salesman meets with wonderful success the first week and then interest lags. Some companies stage additional contests for the second, third and fourth weeks of the campaign. Enthusiasm and good natured contests

Fig. 4. Demonstrations and lectures play a part in bringing the story before the public

should be stimulated by these reports. Daily pep meetings should be held.

Each supervisor should maintain a personal interest in the progress of each salesman in his district. A pleasant inquiry each morning of "Well, how many yesterday? What? Only five! That just pays for the advertising." Or possibly a few words of appreciation will keep the salesman working toward the goal.

Whoopee Ending

Announcing of the results of the contest should be made at a meeting of all contestants preferably at a sales department breakfast. An entertaining program should be arranged. In general this meeting should take on a jolly aspect where the winners are congratulated and the others encouraged to be among the winners in the next campaign.

Conclusion

If you have read this report to this point, the committee has been successful in its attempt to put "life" in its copy. This report is not offered as a final answer to "What makes a Campaign Successful?" The committee believes that the work should be continued so that a study can be made of a greater number of campaign plans.

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*Air Heating**

The work of the air heating committee has this year taken the form of brief reports which are being sent out to member companies and of a lecture which is the joint product of all subcommittees. The committee recommends a continuance of the work now under way.

THE work accomplished by the air heating committee for the past year has been the production of the following brief reports, which are being distributed to the different member companies:

1. A study and development of automatic control and control equipment used in connection with electric space heating jobs.

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* Report of air heating committee, Merchandising Bureau, Commercial Section. H. H. Douglass, chairman. R. H. Robinson, vice-chairman, southern section. C. A. Russell, vice-chairman, northern section. R. H. Bradford, H. H. Daley, O. R. Doerr, A. W. Elliott, W. S. Fleming, C. B. Merrick, M. J. Murphy, P. P. Pine, G. M. Rankin, C. A. Sanborn, C. E. Zelhart.

2. A study and report on the economy of insulation.

3. A study and report on the economy of electric heating, showing a few definite examples of the method of analyzing the comparative costs of different methods of heating. This was outlined in the revision of the 1929 air heating committee's manual.

The points of interest brought out in the different committee meetings during the year have been more or less crystallized in the form of a story, which was presented at the Merchandising Bureau's session on Friday, March 21. A brief summary of this story is here given.

It is presented by means of charts and slides, showing some of the features which enter into the sale of electric space heating. This story has been the joint contribution of the air heating committees.

We recommend to the incoming air heating committee that they devote increased attention to the work already under way and that it be developed and brought to a final definite form for publication in next year's reports.

Appendix—Air Heating in California[1]

We take pleasure in presenting this story of some of the features in connection with the sale of electric space heating, which have developed from time to time on different jobs. This is the hot air story from the hot air gang. We like it, we believe in it, and we intend to stick to our story.

Why is Air Heating?

We are all familiar with the stock reasons of cleanliness, convenience, safety, and the many different reasons for the use of electric space heating, but one of the big reasons for the growth of electric heating in California has been due to climatic conditions. Our climate is such as to require very little heat at any time, and the flexibility and convenience of control of electric heating lends itself very readily to fit our climatic conditions. (Show annual temperature chart, U. S. Weather Bureau, Los Angeles.)

Economy of Electric Heating—

We refer to the heating manual as published by last year's committee. On page 11, we show a method of analyzing the comparative costs of different forms of heating. Economy may be defined as results that justify expenditures, and the comparative costs of heating will not be true unless all of the costs are considered, and they on the basis of equivalent heating. (Show slides of San Bernardino Medical Building cost analysis. We give here a discussion of the different items of cost on this job.) This is an actual job that is going in, and it was sold on a basis of different studies of the engineering economies in connection with the job. "Engineering economies" has been defined by one good authority as a combination of brains and bologna, and it is these very items of engineering economy that we must depend on to put over electric heating jobs in the future.

Some Reasons for Improving Conditions

There are many reasons for the improvement of heating conditions in California, among which may be mentioned the following:

1. Increased activity of the utility companies.

2. Manufacturers' co-operation.

3. Improvement in equipment, such as appearances, design, results obtained.

4. Some new ideas, such as the new fan-type heaters and the Carnot heating cycle system.

5. Increased dealer activity and co-operation. We have found a very marked increase in the heating game due to activity and co-operation of dealers who have been sold on the actual cash-register value of getting completely electrified homes. We have in mind and can cite one job in particular where the bids were submitted for the ordinary electric wiring, amounting to $4,300, where the heating was to be oil-fired steam and the cooking and water heating done with the so-called canned gas, and when the job was completely electrified, the contractor had a contract for $22,000 instead of $4,300, involving the installation of all of the original layout, plus over 200 kw. of electric heat, seven electric water heaters and three electric ranges. This cash-register value of the heating load should be stressed with the trade and a complete tie-in made with the industry.

Classification of Load

The major divisions of load which apply to electric heat may be roughly classified as:

Residential
Apartments
Schools
Hospitals
Commercial and industrial offices.

One of the biggest and best fields and one which has been most neglected, is this item of offices and industrial plants. This has been more or less of a hobby in the south for the past year and special efforts have been made to get this class of load, with the result that some 35 or 40 industrial plants are now using electricity for air heating with splendid results. (Show slides of industrial plants and description of each.)

Thermostatic Control

(Show temperature chart and economy of thermostatic control.)

Thermostatic control is one of the big items which has a tendency to produce the most satisfactory results on electric heating. It is nothing new, as it has been done by the mechanical heating people for years. Its general application produces marvelous results in the satisfaction derived from heating jobs. (Discussion of the economy chart.)

Insulation of Buildings

It has been shown that very definite savings can be made on the cost of heating by the use of adequate insulation. These savings, in many cases, run as high as 50 per cent and an average saving of 40 per cent is easily attained with a well-insulated job. It increases the comfort and satisfaction derived from the building, not only in cold weather, but also in hot weather, and it is safe to say that a correct job of insulation does not actually cost any money, but returns big dividends on the investment involved.

In Conclusion

In conclusion we summarize as follows:

1. We have a large and rapidly increasing field of endeavor.

2. There is a very marked trend toward popular acceptance of air heating.

3. Co-operation between the public service companies, the manufacturers and the trade has an actual cash-register value for each.

4. We should cash in on our climatic conditions for the sale of electric heating.

5. And do not forget the actual economy for the owner when all the costs are considered. California will install approximately 50,000 kw. of electric space heating during the year of 1930 at an approximate cost of $1,000,000, and this business should be sufficiently attractive to bring all the industry together in a united job of selling electric heating as it should be done.

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[1] A synopsis in brief of the air heating committee's presentation of the air heating story at the Merchandising Bureau meeting.

*Report of the Appliance Committee**

IN building, buying or furnishing a home, the owner or prospective owner expects to get a complete bathroom. He does not buy a bathtub first and a few months later a wash basin. Nor does he wait a year to get a medicine cabinet provided he has not spent all his money for a radio set.

Why not buy (or the electrical industry sell) the complete electrical home equipment in the same manner? There has persisted in electrical appliance merchandising, a piecemeal system of buying and selling. The housewife first obtains an electric iron. Later she may purchase a vacuum cleaner. Perhaps then she will buy a washer. Eventually she may have a complete electrical home, if the money has not been spent for something else.

The appliance committee this year had made a study of the latest development in electrical appliance merchandising —the group selling plan—designed to overcome some of the shortcomings of the older methods of appliance selling. This program as adopted by some of the power companies has been studied thoroughly. As a result of its investigations, the committee has reached the conclusion that, like anything new and novel, the plan must be explained and its benefits pointed out to the industry.

In arriving at the method by which this educational work might be done most effectively, the committee hit upon the idea of preparing and producing a playlet based upon the group selling idea. The assistance of Miss Alma Freeburg of the publicity department of the Coast Counties Gas and Electric Company and of Fred Foy of the San Joaquin Light & Power Corporation was secured, and the playlet, "Meet Mr. Santa Claus," was the result. This playlet was produced for the first time at the Commercial Section Conclave in Fresno, March 20-21, 1930, by a cast composed of members of the San Joaquin Light & Power Corporation and the Valley Electrical Supply Company. It elicited much favorable comment.

The appliance committee offers the text of this playlet as its report this year, feeling that a mere reading of it will do much toward furthering the idea of group appliance selling. The committee urges that commercial manager and appliance sales managers take advantage of the manuscript of the playlet and have it produced before sales conventions or before any gathering of electrical men. The complete text of the playlet follows:

Meet Mr. Santa Claus

CAST

Mrs. Larsen, the housewife.
Mr. Vance, the high powered salesman.
John, who knows all about washing machines.
Mr. Reese, the central station representative.
Miss Hill, the bride to be, who is having a struggle to make finances include new furniture.

SCENE:—Living room in an average home, with door leading off stage on one side, which can be used for an outside entrance, and a second door to lead into another room. Room should have rug on the floor, table, chesterfield set, and extra chairs.

An electric iron and cord also will be needed.

As the scene opens, Mrs. Larsen is sitting in a rocking chair by the window, busily sewing. The door-bell rings loudly. With a look of annoyance she puts her sewing to one side and answers the bell. As she opens the door, Mr. Vance, the high-powered salesman, immediatly places his foot in the door so it cannot be closed and begins to talk very hard and fast, so Mrs. Larsen cannot get in a word.

Mr. V.—Good morning, Mrs. Larsen. Isn't this a lovely day? I am A. R. Vance and have called to demonstrate the new "Highpower" vacuum cleaner.

Mrs. L.—But I'm not interested in—

Mr. V.—Oh, but my dear Mrs. Larsen, you must be interested in this new sweeper. It is the most modern and up to date on the market. It is used by many of your neighbors, in fact, it is used in all of the best homes. The "Highpower" is a motor driven, brush type, which authorities concede to be one of the most efficient and practical on the market. It has a full set of attachments, including those for floor polishing.

Mrs. L.—But I'm—

Mr. V.—Also this cleaner can be used with proper attachment for the holding of napthalene or paradichlorobenzene crystals, which are broken into fine particles and forced into the pile of the rugs, aiding in exterminating moths. We also have this small hand cleaner, which is ideal for the cleaning of clothing, draperies, carpets and upholstery, effectively removing dirt, and it is much more convenient to handle than the old method of using attachments with the larger cleaner.

Mrs. L.—But I'm—

Mr. V.—You will be delighted with the ease with which this "Highpower" cleaner will make your rugs look like new. Allow me to demonstrate—

(*Salesman steps through door, picks up small rug, beating it on back with hand causing much dust to be emitted.*)

Now you will see that this rug has been cleaned thoroughly by the mere process of passing the "Highpower" over the surface, yet it is absolutely harmless to the rug, takes up the small particles which result in wear and cutting caused by walking on the rug, and leaves it absolutely clean. You can readily understand that a rug cleaned regularly and thoroughly will give longer and better service than one not given the proper care. You cannot take the best care of your rugs without one of these "Highpower" cleaners.

(*Mrs. Larsen has remained standing until now, but sinks into a chair on attempting again to get in a word.*)

Mrs. L.—This is very true, but—

Mr. V.—You will be delighted with the ease with which the "Highpower" cleans and picks up dirt. Allow me to demonstrate—

(*Scatters a handful of finely torn paper on floor.*)

Mr. V.—We will scatter this finely torn paper over the floor; *(plugs in sweeper)* you realize, of course, how difficult this is to remove with a broom or ordinary cleaner, yet the new "Highpower" removes it with no difficulty. See, every scrap is taken up. Another feature you will note—

(*Removes and opens dust bag, spilling part of contents on floor again.*)

—is the ease of removing the contents of the dust bag.

Mrs. L.—I understand all that, but—

Mr. V.—Another use which is perhaps not so universally recognized, but for which you will find this new cleaner most effective, is that of cleaning bare floors.

(*Moves chesterfield slightly, showing a collection of dust and lint, much to Mrs. L's. embarrassment.*)

See, before the dust mop is used, just adjust the nozzle to its lowest point and it will remove all dust and lint which accumulates beneath beds and furniture.

Mrs. L.—We have—

Mr. V.—But until you have tried one of these new cleaners you do not appreciate of how much service a *real* vacuum cleaner can be. And now for this small model. It is ideal for the cleaning of upholstered furniture.

(*Removes pillow from chesterfield, and puts it down on chair, raising quite a bit of dust, and disclosing handkerchief*

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* Report of appliance committee, Merchandising Bureau, Commercial Section. Pierre Vinet, chairman. A. W. Althouse, vice-chairman. R. F. McDonald, vice-chairman. E. E. Bacon, R. A. Best, J. P. Bowden, L. J. Brundige, O. S. Clifford, H. L. Garbutt, W. C. Greene, W. C. Heston, R. W. Kimberlin, Elbert Kramer, C. E. Louis, E. W. Meise, E. D. Minnick, F. A. Mulvany, C. A. Russell, J. W. Wrenn.

and book placed beneath it, which are hastily removed by Mrs. Larsen.)

Mr. V.—(Disconnecting large model and plugging in small.) With this small model we have a complete service for this type of work.

(Runs cleaner over small section of chesterfield.)

Mrs. L.—It works very nicely, but—

Mr. V.—And another important feature of these cleaners is that they are constructed with the proper type of bearings and need no oiling, which is as it should be for your own interest. I am sure that you cannot afford to be without these two "Highpower" cleaners. *(Takes contract and pencil out of pocket.)* I have made out a contract and all you need to do for these two efficient cleaners to be delivered at your home is to sign on this line. We are making a special offer for a few days of these two cleaners for only $75, 10 per cent down and $5 per month on the balance. Just sign here.

Mrs. L.—But, as I tried to explain before, my husband gave me a "Highpower" cleaner and all attachments for Christmas, but we have had to return it for some repairs, that is why my floors and furniture have not been cleaned. It should be back tomorrow.

Mr. V.—(Crestfallen and making a rather hasty exit.) Oh, I beg your pardon. You should have said so before I took so much time. Thank you just the same. Good day.

Mrs. L.—(Closes door, puts cushion back in place, gathers up the papers left on the floor where he did not run the cleaner and settles down in chair once more and picks up sewing.) A whole half hour wasted. It will be lunch time before I know it.

(Door-bell rings again.)

What, again!

(Mrs. Larsen once more puts her sewing to one side and goes to door. On the threshhold stands a young man, whom she calls by name. He has briefcase in hand.)

Mrs. L.—Why, good morning, John. What are you doing out here during working hours?

John—Well, you see, Mr. Seymour is putting in a new line of washing machines and he thought you might be interested.

Mrs. L.—Well, John, I am—but they are so expensive, although they are a great comfort and convenience.

(While Mrs. Larsen is speaking, they both come into the room and sit down. John takes his pamphlets out of the briefcase and spreads them on table. He unfolds large circular, with photograph of washing machine.)

John—This is the new Deluxe Porcelain Tub Agitator Washer, and has been designed to meet a new demand. Of course this illustration does not do it justice, and we should like to have you stop in and see it—or, of course, we would be glad to arrange a demonstration.

Mrs. L.—Well, it is nice looking, but I have been sending most of my laundry out. The laundries give us such good service and they're really not expensive.

John—But just look at this tub, it is made of Monel metal which gives this washer all the beauty of silver and is everlasting—a solid rustless metal whose luster age cannot affect and which possesses extraordinary strength and durability.

Mrs. L.—I don't know where I'd put a washing machine right now if I did get one.

John—See how this tub is mounted on a heavy pressed steel base, with four pressed steel legs, electrically welded and riveted, then finished in gray lacquer.

Mrs. L.—How much room does it need?

John—Oh, this washer only weighs 146 lb. including its ¼-hp. motor.

Mrs. L.—How much will it wash at one time?

John—It has a capacity of 6 lb. I think it is interesting the way the mechanism is enclosed in cast iron and steel housing. All cut gears.

Mrs. L.—Cut gears? What are cut gears?

John—Why, they are cut gears. Splash lubrication—direct motor drive. The entire mechanism and motor is hung from base stamping, providing absolute stability and protection from moisture and dirt.

Mrs. L.—Can you use an ironer with this machine?

John—Oh, yes, Mrs. Larsen. The swinging wringer is removable, reversible and all metal. And it is cadmium plated and lacquered in gray. It can be locked in four positions, has balloon rolls 12 x 2½ in., a safety release and single tension screw. Oh, yes, and the number 0 attachment ironer fits this model.

Mrs. L.—Is it liable to break down often?

John—We carry a full line of parts and can make any replacements for you. However, this machine has been thoroughly tested in our factory, and is guaranteed for at least fifteen years' service.

Mrs. L.—Well, I am not quite ready to buy a machine yet.

John—I am sure you would be pleased with this machine, if we could just give you a demonstration, so you could see how smoothly and silently it runs, and how sturdily it is constructed.

Mrs. L.—Well, we may be away next week. I don't think we'd better plan a demonstration right now, John.

John—All right, Mrs. Larsen. I'll call back about the first of the month. And I know you'll want one of these washers, at only $129.50. Why, there were more than 1,000,000 washers sold in the United States last year.

Mrs. L.—We'll see. How's your mother?

John—Oh, she's feeling pretty well these days. *(Gathers folders and starts toward door.)* She's just back from a trip up north— Well, I'll see you again soon about this machine. Goodbye. *(Exit.)*

(Mrs. L. draws long sigh of relief and once more settles down to her sewing.)

Mrs. L.—This morning has been the limit. If one more salesman calls I'll wash him in his own suds. And anyway, I never did have a head for figures, though maybe I will need a washer some day. Well, it won't make much difference what metal is in the tub so long as the clothes there get some attention.

(Door bell rings once more.)

Mrs. L.—What, again! If that's another saleman—

(Opens door. There stands the representative from the central station. He will need briefcase, catalogs with photograph of range, water heater, refrigerator, percolator, waffle iron and heater, also small pair of pliers.)

Mr. Rees—Good morning, Mrs. Larsen. *(Hands card bearing name and central station name.)* Our records at the electric office show you are using an electric iron, vacuum cleaner, range and water heater, and we are anxious to know if they are all giving you satisfactory service.

Mrs. L.—Everything but the iron. It doesn't heat properly and I've only had it a short time, too. Maybe that's the trouble. My neighbor says too much short is the trouble with electric things.

Mr. R.—May I take a look at it? Perhaps I can fix it.

Mrs. L.—Of course, come in and sit down while I get it.

(Rees enters and takes chair, while Mrs. L. goes into other room and returns with iron and cord.)

Mrs. L.—My husband tried to fix the voltage, but that didn't help it any.

Mr. R.—(With surprised look.) Voltage? *(Takes iron and cord.)*

Mrs. L.—Yes, he said if he could tighten up the voltage, it might work all right.

Mr. R.—(Hides amusement as best he can.) Oh, I see. Here's the trouble. The wire in the cord is broken, but I can easily fix that.

(*Takes small pair of pliers from briefcase and repairs iron connection while conversation continues.*)

Mr. R.—I am sure you enjoy using your electrical appliances very much, and a little heat would be very comfortable this kind of weather, too, wouldn't it?

Mrs. L.—Yes, it would, and I need some other electric things, but they are so expensive I can't buy now. And anyway, you are about the sixteenth salesman to call here this morning and you might just as well not try to sell me anything.

Mr. R.—But wouldn't you really like to have these appliances, if I can show you how it can be done at a price you can pay easily?

Mrs. L.—Yes-s—but—

Mr. R.—Just what group of appliances would be of the most help—toaster, waffle iron and percolator, or cooker, toaster and air heaetr, or just what would you like most?

Mrs. L.—Say, what is this—a game? Well, I really want a waffle iron, percolator and heater, but I can't afford them. I told you you couldn't sell me anything this morning. That's my story and I'm going to stay with it.

Mr. R.—Purchased separately, the payments do mount up, but your electric company can make this kind of an arrangement with you. The waffle iron, percolator and air heater make an excellent combination, which you can purchase as one unit, making only the usual 10 per cent down payment, and then instead of paying the balance on each in four or six months at the most, it can be arranged in twelve payments, which reduces your payments from one-third to one-half the amount on individual units.

Mrs. L.—Well, that might be all right if the payments were small enough. Remember, I'm just a poor housewife trying to get along.

Mr. R.—In this way you have the convenience of the complete set and can enjoy using all of them right away, without buying first one and then the other. And at the same time, the payments are about the same as for the one appliance.

Mrs. L.—Well, there's nothing wrong with that idea. Have you a good heater for the bathroom?

Mr. R.—For the average size room, we recommend this heater and it is plenty large for auxiliary heat in the playroom or in a bedroom, should anyone be ill. (*Shows illustration.*)

Mrs. L.—Mr. Larsen saw one like that in the window and liked it very much. But how about the waffle iron and percolator. We might as well do this up right.

Mr. R.—(*Showing illustration.*) This waffle iron will probably be most satisfactory to you, although we can offer several types.

Mrs. L.—That'll do, I guess, although Sam is a bad man on waffles. And about a six-cup percolator will be large enough. That's two for me and four for Sam. But now, how much is this going to cost each month? Whatever it is, it's too much!

Mr. R.—These appliances will call for a down payment of only $4, and $3 a month, in place of $6 under the old plan. You will get a great deal of enjoyment out of them, and that's not much to pay!

(*Mr. R. makes out contract while talking.*)

Mrs. L.—Why, that's not much. I can sneak that out of my housekeeping money. Why haven't you been around before, Santa Claus? What the heck have I been doing sitting around without a waffle iron, percolator and heater?

(*At this point Mrs. Larsen's sister, Ruth Hill, bursts into the room and does not see Mr. R at first.*)

Miss H—Oh, Sue, I think every salesman in this town's trying to sell us something for the new house. I never saw so many in my life. (*Sees Mr. R. for first time.*)

Oh—I beg your pardon.

Mrs. L.—My sister, Miss Hill, Mr. Reese. My sister is building a new home on the Heights. (*Turning to sister.*) Mr. Reese has just been explaining to me how to get a heater, waffle iron and percolator for nothing down and a dollar less every month.

Miss H.—But Sue, don't be silly! It can't be done. I ought to know.

Mrs. L.—Take it from me, it can be done. Let him explain, but hang on to your money bags.

Mr. R.—Yes, Miss Hill, I think perhaps this well help solve your problem, too.

Miss H.—Well, let's hear about it. It sounds new, but I've heard a lot of sales talk. I saw the best stove at Parker's and a dandy water heater at Smith's and I need a refrigerator, too, but the payments come to so much we will only be able to get the stove, I guess. It's a hard life. Never be a bride, Mr. Reese.

Mr. R.—Thanks, I won't. You might as well enjoy all three and have the convenience of an electrical kitchen without waiting. We can offer you the range, refrigerator and water heater, in a group with only a down payment of $54.50 and $21 per month, giving you practically twice as long as you usually have to pay for them.

Miss H.—It sounds all right, but there's probably a catch somewhere. Anyway Phil has a friend in the electrical business; also the paint, furniture, shoe and what else have you business, and—

Mr. R.—Of course, he can make arrangements with him to make the installation, and the electric company will carry the account just the same. However, we carry only standard appliances and are in a position to give you the best of service in any case.

Miss H.—Yes, your company is just as regular as Sue says its bills are. And anyway, Phil's friends all turned up when we started to buy. But now, about what size refrigerator would you recommend? One that will hold the food as well as the bottles.

Mr. R.—(*Showing illustration.*) This size is the most satisfactory. The other is too small for the usual home, and is best for only small apartments. And for the range you will need a three-holer, with oven, complete heat control, and I would recommend this one.

Miss H.—Yes, that's right, we have to eat, don't we? Have you got one with an electric can-opener?

Mr. R.—And this water heater will be best with the range. This gives you an excellent start for a complete electrically equipped kitchen, and is much more satisfactory than buying piece at a time. (*Makes contract.*)

Mrs. L.—Well, it looks to me like you're going to buy something today.

Miss H.—Well, that makes two of us, dearie. But I didn't want to buy anything. Now the fun begins. Well, I'll take a chance if you will. (*Signs contracts and makes out check while continuing conversation.*) I don't know whether to tell you to hurry to the bank with this or to hold off. It'll probably come back either way.

Mr. R.—And where should these be delivered?

Miss H.—At 14 Fairwood Heights. The house will be ready the last of next week. Can we have them installed right away?

Mr. R.—Oh, yes. We can deliver them by that time, also we can make you similar arrangements for the purchase of laundry ejuipment, or any other appliances.

Miss H.—But I'm not going to buy any small appliances—maybe we'll get enough given to us so we won't have to! A bride ought to get something out of getting married!

Mr. R.—You will, I think. We will see you about them later then. And Mrs. Larsen, your appliances will be delivered tomorrow. (*Making exit.*) Thank you very much, and be sure to advise us if anything does not operate properly. Good day. (*Exit.*)

Miss H.—(Closing door, looks rather foolishly at her sister and then laughs.) And I came over here to get way from *salesmen!*

Curtain.

(FINIS.)

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*Selling Appliances**

Small appliances have hitherto been somewhat neglected owing to the greater incentive to salesmen in the larger commissions from the sale of the larger equipment. The committee recommends the encouragement of a greater employee interest in appliances, both by selling them appliances for their own use on attractive terms and by suitable commissions offered for the sale of appliances through other than the regular sales force. Attention should be given to repairing or replacing appliances which are obsolete or out of order. The appliance committee believes that the entrance of the central station into the merchandising field greatly stimulates the sale of convenience outlet appliances. The group selling plan is recommended to central stations for their consideration as a means of increasing kilowatt-hour consumption.

THE appliance committee for the years 1929 and 1930 consisted of nineteen representatives from all parts of California, Reno, Nevada, and Phoenix, Arizona. These men not only represented various central stations in these western states, but included also representatives of manufacturers or distributors of standard electrical appliances. The subjects outlined herein, therefore, were discussed from various angles, the manufacturer's viewpoint, the central station angle, and the customer's needs all being considered.

It was the purpose of this committee to discuss and make plans for a greater distribution of convenience and outlet appliances.

It was generally agreed that central station salesmen, working on a commission basis, found it more profitable to sell the larger appliances and naturally neglected somewhat the sale of smaller appliances. It was generally agreed that manufacturers, dealers and central stations should make an effort to encourage a greater employee interest in merchandising. This interest is to be created through the use of more appliances by the employees, to be made available at more substantial discounts. It was felt, also, that this could be accomplished by having manufacutrers or distributors prepare displays for employees only, the idea being to acquaint them better with the latest electrical devices. There is no question in any one's mind that the employee familiar with appliances being sold by his own company is one of the greatest advertising mediums obtainable.

To tie in with this, it is further recommended that a fair remuneration be given employees (excluding, of course, regular sales people) to increase appliance sales by the rank and file.

The subject of proper compensation was discussed from various angles, but the committee feels that this is a problem for each individual central station to decide.

The advisability of merchandising electrical appliances on the family budget plan was discussed. This subject was brought up for discussion because of the fact that many other merchants, outside of the electrical industry, are very successfully using such a budget plan. This subject was also left to the individual central station for its personal adjustment.

It was generally agreed that more kilowatt-hours per customer could be sold through the rehabilitation, or trading in, of appliances now in customers' homes.

Many homes have appliances that are not being used, due to the element being burned out, or the appliance not having received proper service. The recommendation along this line was that if such a case comes to the attention of employees of the central station, efforts should be made to interest the customer in servicing this appliance so that it can be properly used, or he should be encouraged to replace it completely, or trade it in, where such arrangements can be made on a newer appliance.

It is the observation of the appliance committee, borne out by facts, that convenience outlet appliance activity is far greater in communities where the central station is aggressively merchandising. Many central stations are greatly increasing the kilowatt-hour consumption per domestic meter through harmonious dealer co-operation.

A great deal of discussion has been going on throughout the country among central stations, manufacturers and dealers, as to the group selling of electric appliances. This plan, in brief, is one whereby every effort is made to sell a customer two or more appliances at one time. In cases of this kind longer terms can be arranged.

The appliance committee recommends to the Merchandising Bureau that this group selling idea be given a great deal of thought by all central stations who are desirous of immediately increasing their kilowatt-hour sales to their individual customers. It must be understood that this is not only applicable to convenience outlet appliances, but the groups can be arranged to suit the customer's needs. In other words, a group can consist of a refrigerator, range and water heater, or range, water heater and air heater, as well as a group of table appliances. These groups, as stated should be arranged as needed by the central stations and to suit the requirements of each customer.

It is thought that group selling should not materially increase down payments or monthly payments.

The appliance committee has written and produced a playlet, on this subject, depicting exactly how this group selling plan works out, using as a comparison the sale of one appliance as against two, three, or more. This playlet is short and to the point; copies can be obtained by referring to the appliance committee.

The committee feels that in the above outline it has pointed out the most modern ways and means whereby small appliances can fit into the Pacific Coast Electrical Association's program for this year, and can assist in carrying out their slogan, "More Kilowatt-Hours per Domestic Meter."

* Prepared for appliance committee, Merchandising Bureau, Commercial Section. Pierre Vinet, chairman. A. W. Althouse, vice-chairman. R. F. McDonald, vice-chairman. R. E. Bacon, R. A. Best, J. P. Bowden, L. J. Brundige, O. S. Clifford, H. L. Garbutt, W. C. Greene, W. C. Heston, R. W. Kimberlin, Elbert Kramer, C. E. Louis, E. W. Meise, E. D. Minnick, F. A. Mulvany, C. A. Russell, J. W. Wrenn.

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*Commercial Cooking**

The commercial cooking committee this year has concentrated upon the obtaining of publicity, both within the member companies and in trade magazines.

THE commercial cooking committee this year concentrated upon the obtaining of publicity, both within the central station organizations and in trade publications. The plan in brief was as follows:

* Report of commercial cooking committee, Merchandising Bureau, Commercial Section. H. F. Huggins, chairman. E. G. Alberts, A. Anderson, O. F. Anderson, W. R. Bowler, R. A. Best, G. W. Cole, L. A. Francis, H. L. Garbutt, J. C. Hoyt, P. P. Pine, G. Switzer, H. E. Welsh, Geo. Zelhart.

1. Each salesman was to obtain photographs and operating data on any installations of interest in his territory, bringing out any special features and advantages.

2. He was to arrange for publicity in house organs or trade magazines in his territory.

3. He then sent copies of the photographs and reports to the chairman of the committee, who endeavored to obtain further publicity in local or national publications in other districts.

4. The chairman also distributed this material to any salesman who requested copies. This made it possible for the specialist to keep posted on the newest and best installations in other districts for use in selling the electric idea to prospects interested in similar installations.

The committee has been successful in having a number of articles published in such trade papers as *Western Baker, Cafeteria Management, Western Restaurant and Pacific Marine Review.* The committee has on file for later use a number of interesting photographs and data pertaining to commercial cooking installations.

The committee recommends a continuance of the present policy for the coming year, as it believes the future of electric cooking equipment rests largely in the hands of the power companies and that if their employees are thoroughly acquainted with the possibilities of this type of equipment, it will materially help its sale.

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*Selling Ranges**

THE results of the work of the various subcommittees of the 1929-1930 range committee are as follows:

Employee Range Campaign
R. E. Larson, chairman.

The work of the committee consisted of planning and carrying on an employees' range campaign, embracing all employees of the electrical industry. Because of the wide scope of the activity final reports are not available. However, we feel that the final results will show approximately 1,000 ranges sold.

Educational Subcommittee
A. W. Krueger, chairman.

The educational subcommittee arranged for the presentation of a talk on "The Home Electrical" before service and women's clubs and other like gatherings. Through these talks they were able to put over the electrical home idea to between 2,500 and 3,000 people. Direct sales have been traced to these talks, so there is no doubt of their merit and desirability.

Proved Campaign Methods
A. F. Morairty, chairman.

This subcommittee's work consisted in the gathering of proved merchandising ideas and practices and in setting up a program of procedure for laying out successful campaigns. This committee has succeeded in putting out a very valuable piece of work which it is hoped will be of use to member companies in future campaigns.

Minimum Range Wiring Specifications
P. V. Moffatt, chairman.

This subcommittee continued with the work of last year's range committee in getting a more general acceptance of the minimum range wiring specifications. They were particularly successful in that they have added, to the original list of 103, nine more cities that have adopted the specifications.

Water Heating Subcommittee
H. H. Fogwell, chairman.

This subcommittee undertook the revision of the last P.C.E.A. Water Heating Manual. The work has been carried to completion, but owing to the lack of funds will not be printed this year.

Recommendations

The range committee has the following suggestions to make:

1. That employee range campaigns be conducted next year.
2. That a water heating committee be appointed, apart from the range committee, that this committee be headed by this year's subcommittee chairman, and that the work of the present water heating subcommittee be carried to completion next year. That next year's water heating committee consider the advisability of an employees' water heater campaign.
3. That further work be done on the acceptance of the minimum range wiring specifications.
4. That next year's range committee investigate the possibility of the convenience outlet for range installations.

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*Selling Electric Refrigeration**

The refrigeration committee this year has endeavored to develop a more friendly competitive spirit in the selling of electric refrigerators. A survey of employees of electric companies revealed that 5.1 per cent own electric refrigerators. The committee recommends that greater attention be paid to employee sales, that the manufacturer be urged to make more liberal terms to employees of the electrical industry and that a co-ordinating body be formed to aid in establishing uniform merchandising policies on the part of all selling electric refrigerators.

THE committee on refrigeration has made a definite effort to develop a more friendly competitive spirit between the sales organizations of the various electric refrigerator companies. This work is of such a nature as to make impossible accurate measurement of results, but the committee believes that its overtures have been worth while.

A survey covering seven establishments in the electrical industry on the Pacific Coast shows that of a total of 16,938 employees, only 1,014 are electric refrigerator users. This is approximately 5.1 per cent saturation. The committee recommends that sales campaigns aimed primarily to develop consumer acceptance of the electric refrigerator, be turned inward and made effective by increasing employee sales.

This committee participated in the work of presenting an educational playlet at the Fresno conclave depicting some of the problems met by the merchandising salesmen.

Believing that the electrical refrigerator has not been as thoroughly sold to the members of the industry as have other comparable appliances, the committee has the following suggestions to make to the executive committee of the Commercial Section:

1. That the national refrigerator committee be urged to use its influence in the promotion of a more liberal policy on the part of manufacturers in the matter of prices on refrigerators sold to the employees of the electrical industry.
2. That a co-ordinating body of the P.C.E.A. be formed with a view to establishing uniform merchandising policies on the part of manufacturers, distributors, dealers and utilities handling electric refrigerators. It is felt that this co-ordinating body might be either a separately organized group, or that this activity might be assigned to some section or committee already functioning.

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* Report of the range committee of the Merchandising Bureau, Commercial Section. W. S. Fleming, chairman. P. H. Booth, R. C. Bragg, C. H. Calef, J. A. Clark, H. J. Drexel, A. W. Elliott, C. M. Hess, J. H. Jamison, A. W. Krueger, Myron McNeal, J. H. Mead, E. W. Meise, P. V. Moffatt, A. F. Morairty, E. F. Perkins, Monty Pfyl, G. M. Rankin, J. S. Ross, R. M. Turnbull, J. W. Wrenn.

* Report of refrigeration committee, Merchandising Bureau, Commercial Section. R. G. Kenyon, chairman. W. C. Heston, A. W. Krueger, G. Little, E. W. Meise, E. A. Norton, C. H. Paulin, R. T. Stephens, J. R. White.

POWER & HEATING BUREAU REPORTS[2]

*Agricultural Power**

CONCLAVE CENTER OPERA HOUSE

POWER BUREAU SHOWS CO.

Presents

SIMON DIGGINTOILER, STRANGER!

or

THE CURSE OF MISUNDERSTANDING

By FRED C. FOY

A Drama of the Public Utility Business in One Act
With an All-Star Cast

CHARACTERS
(as they appear)

Jack Dalton, too busy to realize	Mr. Fred C. Foy
Patience Browning, who pays the mortgage	Miss Betty Drummond
Simon Diggintoiler, not as mean as he looks	Mr. Garrett Van Buren
Aubrey B. Slick, the modern business man	Mr. Sydney W. Green
Auditory Assistant, seldom seen	Mr. Howard W. Sullivan

—o—

Place—Virginity Hollow Office, Great American Power Co.
Time—1897.

—o—

SYNOPSIS

"I fear he is in a temper." "Curse you, Jack Dalton." Diggintoiler's news. "You can't do that!" A farmer's savings. "I can explain." A simple farmer wins. The threat. Fair womanhood suffers. The succor. Enter the oil man. "Why do you use it?" The many reasons. The eavesdropper. "You Win, Mr. Diggintoiler." The light begins to dawn. "I can stand no more." Both were wrong. Tomorrow we enter a new day.

—o—

Scenery	Mr. Jack Carter
Properties	Mr. Howard Sullivan
Costumes	Eitel Hatter, Roos Bros.
Music	Professor Claude Sterling
Organ	Falkenstein Music Co.

—o—

The audience is earnestly requested not to throw peanut shells on the floor as it not only disturbs the actors but increases the fire hazard. The Power Bureau Shows Company specializes in clean, wholesome entertainment suitable for young and old. Children in arms or under sixteen years of age not admitted without parents. We thank you and solicit your renewed patronage.

In case of fire, walk, do not run, to the nearest exit.

THANK YOU.

Fig. 1. Program of the playlet enacted by the agricultural power committee.

The agricultural power committee this year has revised the Agricultural Handbook and in addition has prepared and enacted a scenario presenting the story of farm electrification.

DURING the past year the agricultural power committee has revised and added to the Agricultural Handbook, carrying out the suggestions made by the outgoinng committee of 1929 and making further changes as experience showed these to be desirable. Among the additions made are:

Page 13. Table on horsepower required to lift varying amounts of water through various heads.
Page 15. Frances formula for wier flows, also orifice discharge table and formula for submerged orifices and table on amounts of water required for crops on different soils.
Page 17. Discussion on the preparation of water reservoirs.
Page 19. List of references.
Page 31. List of references.
Page 60. List of references. Poultry house lighting.

The subject of dehydration has been revised to include all farm products which may be dehydrated.

In addition to this work, the committee has concerned itself with the preparation of the outline of a scenario which should correctly and effectively portray by picture and spoken word the desirability of farm electrification.

*Industrial Heating**

The objectives of the committee during the year have been:

1. Sponsoring and conducting the Pacific Coast Section industrial heating school.

2. Preparation of industrial heating film, showing Pacific Coast installations.

3. Compilation of portfolio of advertising matter on industrial heating now being issued and distributed in P.C.E.A. territory.

4. Promotion of attendance at the national industrial heating school.

THE industrial heating committee is pleased to submit the following report on its program as outlined for the year:

Industrial Heating School—The committee's plan of holding a Pacific Coast Section industrial heating school has been definitely set aside, as the committee has been successful in inducing the national industrial heating committee to hold the national school in California this year. The committee feels that this is a real accomplishment and that the benefits to this section to be obtained from this school will be more far-reaching than any other activity in which the committee could engage.

Your industrial heating committee has been asked to act as a committee on arrangements for this school and has accepted the obligation. The date of the national school has been set for June 3 to 13, inclusive, and the place at Los Angeles. In accepting the responsibility of the school, your committee has obligated itself to be in continuous service until June 13.

Industrial Heating Film—The preparation of the Pacific Coast industrial heating film was dropped due to the excessive cost of production.

Advertising Portfolio—The industrial heating advertising portfolio has been compiled in completed form. It is hoped that the brief

[2] E. G. Stahl, San Joaquin Light & Power Corporation, chairman, R. C. McFadden, Southern California Edison Company, vice-chairman.
Central Arizona Light & Power Company: R. H. Bradford, C. T. Yates.
Coast Counties Gas & Electric Company: F. D. Beardsley.
General Electric Company: E. J. Cipperly, W. J. Delehanty, E. M. Ellis, C. R. Owens, M. Rhine.
Great Western Power Company: G. W. Bernhard, H. E. Brillhart.
Los Angeles Bureau of Power & Light: C. H. Dye.
Nevada Valleys Power Company: Noel Pike.
Pacific Gas and Electric Company: P. S. George, W. H. Park, T. A. Wood.
San Diego Consolidated Gas & Electric Company: P. P. Pine.
San Joaquin Light & Power Corporation: A. D. Church, G. E. Zelhart.
Southern California Edison Company: R. H. Cates, G. N. Hawley, R. C. McFadden, C. C. Stewart.
Southern Sierras Power Company: W. R. Chawner, D. B. Wheelock.
University of California: Ben D. Moses.
Wesix, Inc.: A. Strauch.
Westinghouse Electric & Manufacturing Company: J. H. Fenton, W. P. L'Hommedieu.

* Report of agricultural power committee, Power and Heating Bureau, Commercial Section. T. A. Wood, chairman. R. D. Beardsley, R. H. Bradford, H. E. Brillhart, W. J. Delehanty, P. S. George, Prof. Ben. D. Moses, D. B. Wheelock.

* Report of industrial heating committee, Power and Heating Bureau, Commercial Section. R. C. McFadden, chairman. G. W. Bernhard, E. J. Cipperly, C. H. Dye, G. N. Hawley, C. R. Owens, A. Strauch, G. E. Zelhart.

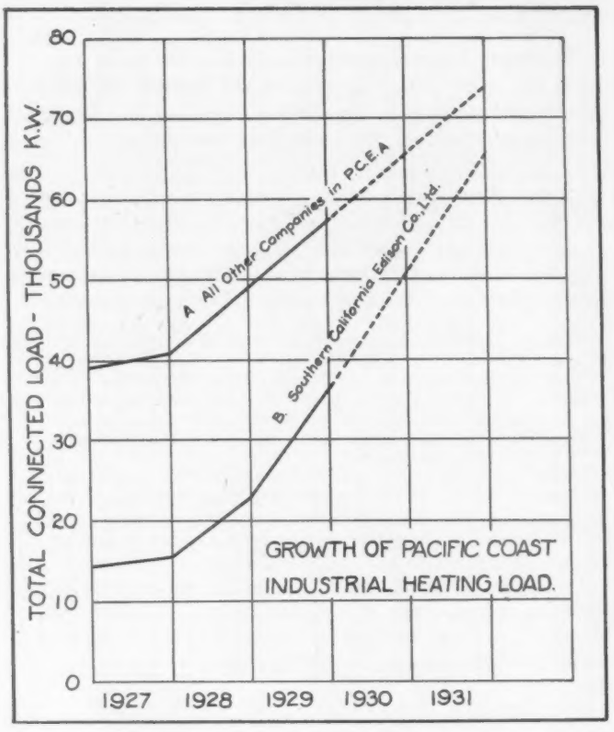

Fig. 1. Curves showing effect of sales effort on growth of industrial heating load.

story contained in this portfolio will act as a stimulus to the advertising and commercial executives among the Pacific Coast power companies, not only to make a greater use of available industrial advertising matter supplied by the manufacturing companies, but also to develop and expand their own advertising program for the purpose of more aggressively campaigning for this load.

If the committee's work in this respect is in any manner successful, the time and expense involved in compilation of this portfolio will have been justified.

Attendance at Heating School—The promotion of attendance at the national industrial heating school is now one of the most important tasks of this committee. As the school is being held in our territory, it is more incumbent than ever upon us to obtain attendance, as attendance will, to a large extent, be the measuring stick of the school's success.

Bringing this school into our midst will make available to our power salesmen a great deal of information which in the past has come to them second-handed. It is hoped that the commercial managers of this section will recognize this educational opportunity for their power salesmen and will respond by sending just as many of their men as possible.

A Plea to Power Company Commercial and Advertising Manager of the Pacific Coast Electrical Association[1]

The industrial heating committee of the Pacific Coast Electrical Association has decided that industrial heat is just as much a commodity which will permit itself to be sold by modern merchandising methods as any other service or product which the utilities have to offer. The committee believes that it is possible to present an advertising sales message to the possible user of industrial heat in such a manner as to arouse, first, an interest, and second, a desire. The advertis-

[1] Prepared by the industrial heating committee as an introduction to the advertising portfolio on industrial heating.

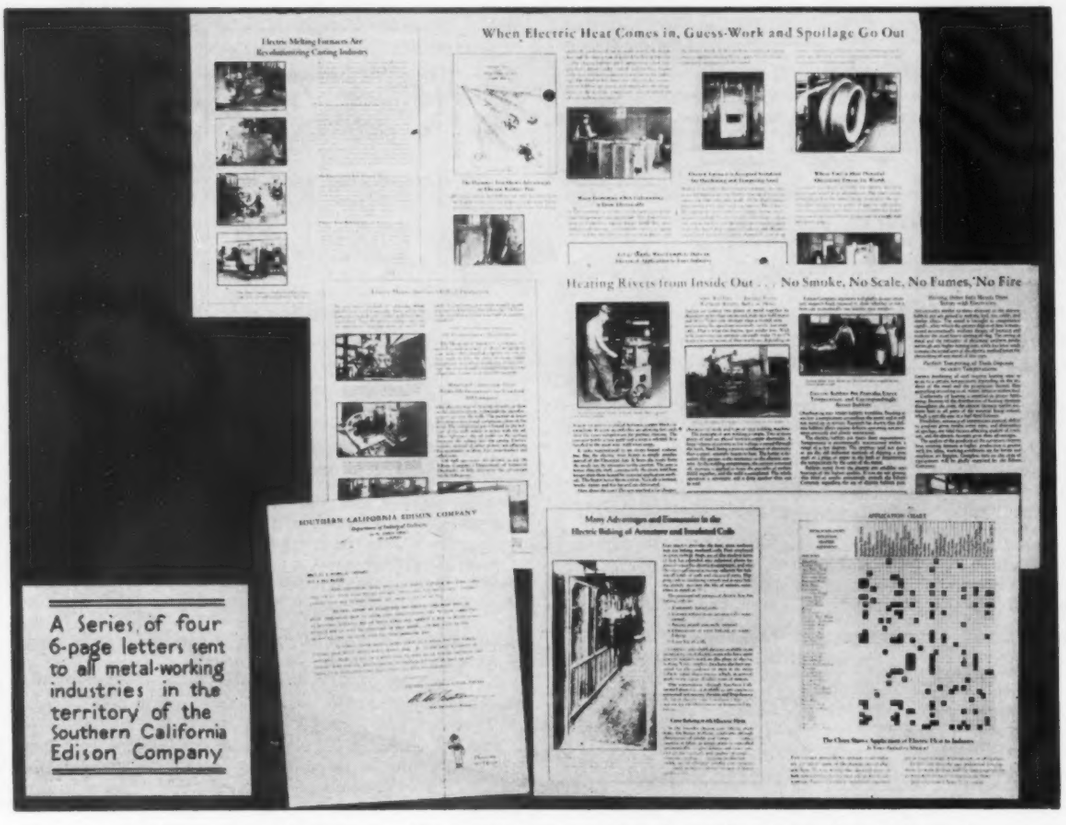
When Electric Heat Comes in, Guess-Work and Spoilage Go Out
Heating Rivets from Inside Out . . . No Smoke, No Scale, No Fumes, No Fire
SOUTHERN CALIFORNIA EDISON COMPANY
A Series of four 6-page letters sent to all metal-working industries in the territory of the Southern California Edison Company

Fig. 2. A series of four 6-page letters sent to all metal-working industries in the territory of the Southern California Edison Company.

A monthly house-organ dealing with the application of Electricity to agriculture and industry
Sent to 25,000 Southern California Edison Co. Consumers..

Fig. 3. A monthly house organ dealing with the application of electricity to agriculture and industry, sent to 25,000 Southern California Edison Company consumers.

Trade Journal and Newspaper Advertising used by the Southern California Edison Co. to tell the story of electrical heat...
The Electric Dairy Sterilizer beats the Old-Fashioned Methods
Use Electricity for Incubating and Brooding Chicks..
Electric Heat Treating Insures Quality Products
Electricity can be economically used to...
Oil Field Tools are Hardened ELECTRICALLY
SOUTHERN CALIFORNIA EDISON COMPANY
POWER for the Oil Industry
Electricity Dominates in the Oil Industry
ELECTRICITY operates heat treating furnaces

Fig. 4. Trade journal and newspaper advertising used by the Southern California Edison Company to tell the story of electrical heat.

ing booklet on industrial heating depicts some of the methods whereby this sales message may be carried to the consumer.

The industrial heating load is available; it goes without saying that it is desirable. It is the business of the power companies and manufacturers of industrial heating equipment to locate the potential user for industrial heating and when that potential user is located, to carry on a selling campaign which will prove to the prospect the desirability and actual necessity for using electric heat.

The advertising campaigns which are shown in the booklet are relatively inexpensive. The revenue which can be produced from even one sale of the industrial heating idea is, in many cases, more than sufficient to repay all necessary advertising costs which may have been expended.

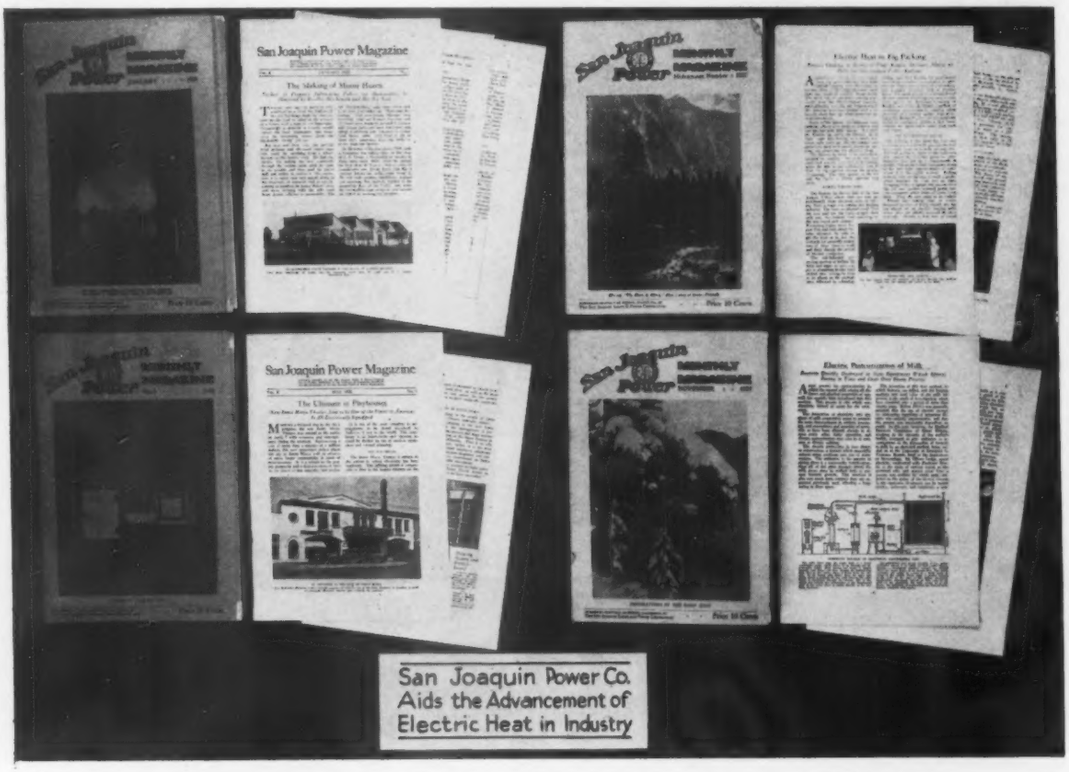

Fig. 5. San Joaquin Light and Power Corporation aids the advancement of electrical heat in industry.

Curve A (Fig. 1) indicates the trend of growth of the industrial heating load in California, exclusive of Southern California Edison Company territory. Curve B (Fig. 1) indicates the trend of growth in southern California where some effort has been made to secure this class of business by tying in with the manufacturer's advertising.

With industrial heating business available which offers a revenue of at least $20 per hp. per year, together with excellent power factor and load factor characteristics, the committee feels that greater support in this work is merited. The accompanying illustrations of advertising material are presented simply to emphasize the condition shown in curve B, namely, that greater results can be obtained if a more widespread use is made of the available advertising material and if reasonable advertising appropriations are directed toward obtaining this class of business.

*Competitive Power**

During the past year the general power committee has collected data on the following subjects:

I. Competitive power
- *a. Diesel engines*
- *b. Natural gas engines*
- *c. Steam turbine condensing*
- *d. Steam turbine delivering process steam*

Detailed information has been secured on the following points affecting all of the above prime movers:

1. *Legality of proposed undertaking*
2. *Financing*
3. *First cost installed*
4. *Operating costs*
5. *Overhead charges*
6. *Type of contracts submitted by engine salesmen.*

II. Operating steam hammers by air electrically compressed.

(This information was secured at request of the general power committee of the N.E.L.A.)

* Report of general power committee, Power and Heating Bureau, Commercial Section W. R. Chawner, chairman. F. D. Beardsley, G. W. Bernhard, R. H. Cates, A. D. Church, C. H. Dye, E. M. Ellis, W. P. L'Hommedieu, W. H. Park, Noel Pike, P. P. Pine, M. Rhine, C. T. Yates.

III. Electrification of oil fields.

(This has been a special committee headed by C. C. Stewart of the Southern California Edison Company, Los Angeles.)

These data, while of exceedingly great importance to power salesmen, are too voluminous for presentation in a report of this character. They will form the basis for a mimeographed handbook which will be made available at a later date. The committee, however, feels that there are certain phases of the competitive power situation that should be brought to the attention of every division of the power companies of the territory. This information is included in the following report.

Overhead Costs—

Overhead costs, including interest, depreciation, insurance and taxes, vary from 1.0c per kw.-hr. to 1.8c (Fig. 1).

Total Costs—

Total costs vary from 2.1c per kw.-hr. to 3.1c per kw.-hr. for best practice, although figures as high as 7.44c per kw.-hr. have been received for a 120-hp. plant, annual load factor 25 per cent. Against this, for larger installations, such as Phelps-Dodge of 9,000 hp., operating figures of 0.83c to 0.982c per kw.-hr. are claimed.

Fig. 1 shows graphically the first cost and annual fixed charges for Diesel engines varying with load factor. While a 100-hp. Diesel can be bought for approximately $68 a

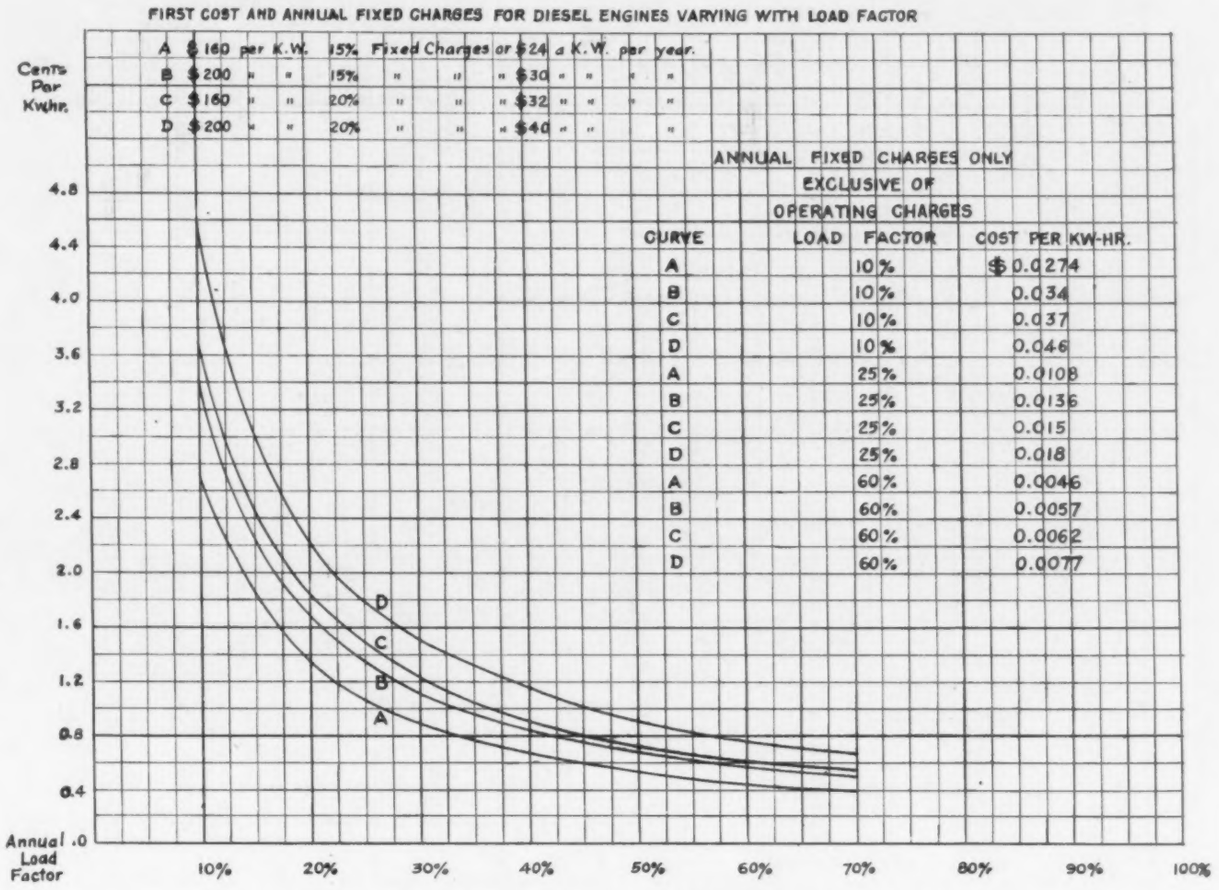

Fig. 1. First cost and annual fixed charges for Diesel engines varying with load factor.

Diesel Engine Costs

THE operating cost of an average Diesel plant has changed very little from last year, with the exception of the fluctuation in the price of fuel oil. Due to the gas conservation law and the consequent curtailment in production of oil, it is anticipated that the price of fuel oil will take an upward trend.

Operating Costs—

Operating costs of an average Diesel engine from 100 hp. to 500 hp. with a 25 per cent load factor would appear to be as follows:

Diesel electric plant.....1.3c per kw.-hr. on switchboard
Diesel direct drive plant....1.2c per kw.-hr. on driven shaft or pulley
Diesel engine alone.....1.1c per kw.hr. on engine driver shaft

horsepower, f.o.b. Los Angeles, the installed cost will run approximately $100 a hp. delivered, say, 80 miles from Los Angeles. On the other hand a Diesel electric plant will probably cost $200 per kilowatt installed and the chart in Fig. 1 has been prepared to show the fixed charges incurred. These are the charges which the engine salesman attempts to cover up, either by his usual purchase-out-of-savings plan or time payment basis.

A chart is also included showing estimated costs for three 500-hp. Diesel engines direct connected to three 333-kw. generators.

Additional information regarding operating costs of Diesel plants is contained in Tables I, II, III, and IV.

"Industrial Power" in January, 1930, issue gives the following table of number of internal combustion engines with

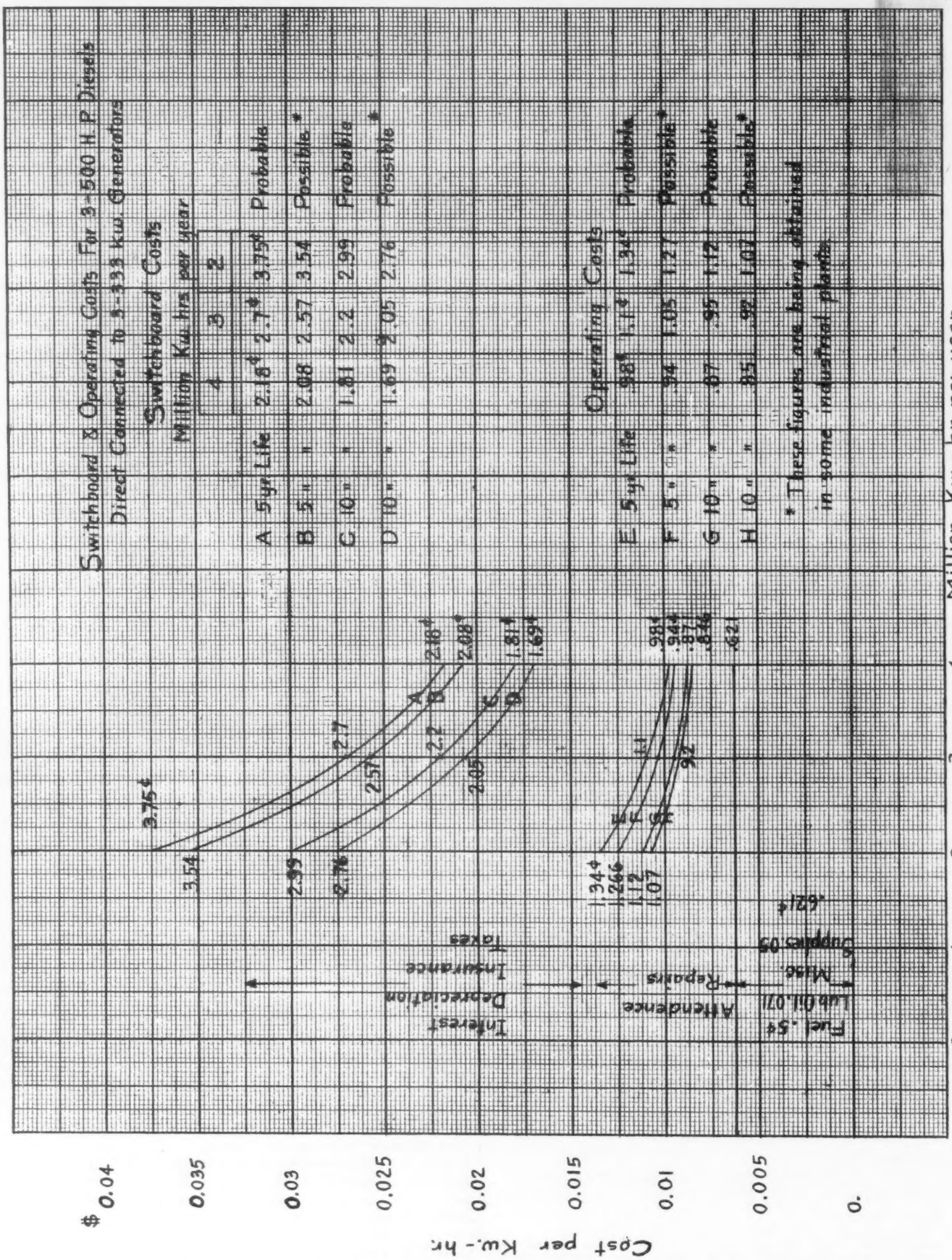

Fig 2. Switchboard and operating costs for three 500-hp. Diesel engines direct connected to three 333-kw. generators.

their total horsepower for the United States for various years:

NUMBER OF UNITS AND TOTAL HORSEPOWER OF INTERNAL COMBUSTION ENGINES

Year	*No.*	*Total Power*
1889	.....	8,930
1899	14,334	134,742
1904	21,515	289,423
1909	34,356	751,186
1914	37,483	993,506
1919	30,813	1,258,308
1923	15,718	1,224,172
1925	14,454	1,188,082
1927	12,663	1,170,759

Discussing this table, the article in question says:

Some of the units run as high as 4,000 hp., but the average capacity is approximately 200 hp. It is reported that around 440,000 hp. of Diesel engines are installed annually, most of them of the mechanical injection type.

TABLE I

Reference	Years Data Cover	Installation: No. of Engines	Total Hp. Installed	Annual Output kw.-hr.	Peak Load Kw.	Annual Load Factor in Per Cent
1	7	2— 100-hp.	200	.....	.....	.....
2	1-1926	3	405	470,500	135	17.8
3	1-1927	1— 150-hp.	350	317,500	....	....
	.....	1— 200-hp.	....	.....	....	....
4	1-1927	.....	9,000	19,868,720	....	....
	1-1926	.....	9,000	19,706,980	....	....
	1-1925	.....	9,000	21,482,180	....	....
5. Utility	1-1927	6	3,940	11,500,000	3,450	38.5
6. Ice	1-1928	2	360	659,977	186	....
7. Mechanical Engineering, August, 1928, P. 593	.....	2— 330-hp.	660	1,761,000	440	46.0
	.....	.....	....	.....	....	....
8. Palo Alto	1-1927	3—1,750-hp.	1,750	1,209,010	1,200	11.5
9	1-1927	2— 950-hp.	3,940	10,848,000 net	....	....
	.....	2— 520-hp.	....	11,500,000	3,450	38.5
	.....	2— 500-hp.	....	.....	....	....
10. Oil Power	.....	.....	....	.....	....	....
11. Oil Power, October, 1928	1-1928	2— 600-hp.	4,312	8,667,825	2,900	34.0
	.....	1— 750-hp.	....	.....	....	....
	.....	2—1,180-hp.	....	759,020 Plant	...	....
				7,908,805 Net		
12. Power Plant Engineering	1-1927	1— 365-hp.	{1,465 (986 kw.)	1,955,080 Gross	580	22.64
	.....	2— 250-hp.	....	.....	....	....
	.....	1— 600-hp.	....	.....	....	....

TABLE II

Reference	Pound of Fuel Per kw.-hr.	Kw.-hr. Per Gal. of Lubricant	Maintenance and Repairs Cents per kw.-hr.	Misc. Supplied Water, Etc. Cents per kw.-hr.	Operating Costs Per kw.-hr.	Total Cost Per kw.-hr.
1	.....	...	($21,034)	(over 7 yrs.)	.....	.....
2	0.846	716	0.594c	0.051	2.809c	4.686c
3	1.420	1.50	0.765	....	4.120	8.650
4	0.680	...	0.064	0.014	0.830	.....
	0.700	...	0.088	0.018	0.875	.....
	0.735	...	0.098	0.018	0.982	.....
5. Utility	0.794	445	0.290	0.038	1.330	2.080
6. Ice	1.040	220	0.120	0.050	1.540	2.270
7. Mechanical Engineering	0.670	900	0.130	....	1.040	1.380
August, 1928, P. 593	....	...	....	....	.....	.....
8. Palo Alto	.....	...	0.610	....	1.200	2.300
9	0.794	445	0.290	0.038	1.330	2.080
10. Oil Power	0.780	455	0.213	....	1.188	.....
11. Oil Power— October, 1928	1.540	5,318	0.102	....	0.908	1.740
12. Power Plant Engineering	0.666	855	0.106	0.048	1.338	.....

The first figures available concerning all types of internal combustion engines, show that a total of 8,930 hp. was installed in 1889. Unfortunately the number of units in service that year was not ascertained, so the average hp. could not be computed. However, starting in 1899 the average hp. increased until it was 40.7 in 1919, and 78 in 1923. The 1927 average was 92.5 hp. and probably was higher than last year. It will be noted from accompanying table that the total horsepower produced by internal combustion engines started to decline in 1919, but since the total number of units has declined at a greater rate, the average horsepower has increased.

TABLE III

Reference	Engines	Generators	Total Investment	Unit Investment: Per B. hp.	Per Kw.
1-A	2 100-hp.	.....	$22,060	$110.00	....
1-B	2 100-hp.	.....	35,174	175.00	....
1-C	2 120-hp.	2 75-kva.	62,639	.....	$261
	1 165-hp.	1 150-kva.	.....	.....	....
1-D	1 165-hp.	.....	.....	93.00	....
3	1 200-hp.	1 135-kw.	16,540	83.00	....
3	1 200-hp.	1 135-kw.	27,637	138.00	205
4	.....	1,500-kw.	.....	.....	160
		7,500-kw.	.....	.....	125
6	1 120-hp.	None	29,328	81.50	....
	1 240-hp.	.....	.....	.....	....
7	2 330-hp.	440-kw.	.....	91.00	137
8	3 1,750-hp.	1,200-kw.	356,368	203.00	297
12	1 365-hp.	240-kw.	19,356	53.00	....
	1 365-hp.	240-kw.	35,000	96.00	....
	1 250-hp.	168-kw.	29,500	118.00	....
	1 600-hp.	410-kw.	38,000	63.33	....
13	3 590-hp.	376-kw.	164,923	98.20	146
14	1 360-hp.	None	23,250	65.00	....
15	1 480-hp.	320-kw.	37,800	79.00	118

TABLE IV

Reference	Date of Installation	Notes
1-A	1920	Engines only.
1-B		Engines, building and auxiliaries.
1-C	1925	1 165-hp. engine and three generators added in 1925.
1-D	1925	Engine only, f.o.b. plant.
3	1924	Engine, generator and 7½-kw. exciter, f.o.b. plant only.
3		Erected and installed complete.
4		Western Division Mining Congress, Los Angeles, Sept. 10, 1925. Phelps-Dodge; includes building, H. H. Pratt, chief engineer. Phelps-Dodge, Douglas, Arizona.
7	1927	Probably no building included, Diesel set-up.
8		Palo Alto municipal used for peak cutting, 1926–27, 18th Annual Report.
12	1915	Engines alone installed.
	1915	
	1920	Engine, Busch-Sulzer type B vertical, four-cycle, high pressure air injection, four-cycle.
	1927	Engine, Busch-Sulzer type B vertical, four-cycle, high pressure air injection, 6-cycle.
13	1928	
14	1927	Full Diesel, direct drive, with all equipment, including circulating pumps, cooling tower, 5-kw. generator, switchboard, pulleys and belting.
15	1927	As above, but with generator, f.o.b. 225 miles from Los Angeles.

Extensive studies regarding the cost of operation of Diesel engines have been made by the American Society of Mechanical Engineers. Through the courtesy of that organization the committee is permitted to reproduce in Table V. results of a number of studies of installations in this country.

GAS ENGINE COMPETITION

Gas engine competition is becoming more and more intense. True, operating costs on these engines have been hard to obtain. A new 60-hp. gas engine delivering a load of around 53½ b.hp. on pumps was checked to consume 3,000 cubic feet of gas in 4½ hours so that our claim of 12½ cubic feet of gas per b.hp. seems to be well substantiated, though the manufacturer claims ten cubic feet.

Lubricating Oil—

The same engine consumed one gallon of 24c oil in seven hours on the same load, or 374½ b.hp.-hr. per gal. against the manufacturer's claim of 1500 b.hp.-hr.

TABLE V By kind permission of the A.S.M.E. the following operating costs on Diesel engines are submitted. These were published by the A.S.M.E. June, 1929.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20						
																			Operating Costs in Mills per Kw.-Hr.						
Plant Number	Number Engines in Plant	Total B. Hp. Installed	Equivalent Kw. Installed	Annual Output of Plant (Kw.-Hr.)	Engine Hours Run	Peak Load on Plant During Year (Kw.)	Annual Plant Load Factor Percent	Running Plant Capacity Factor Percent	Service Factor Percent	Hours Run Per Day Maximum	Hours Run Per Day Minimum	Cost Per Gallon Fuel Oil (Cents)	Cost Per Gallon Lubricating Oil (Cents)	Fuel Oil Used Per Kw.-Hr. (Pounds)	Lub. Oil Used Per Kw.-Hr. (Gallons)	Rated B. Hp. Per Gal. of Lub. Oil	Attendance No. per Shift Shifts per 24 Hr.	Kind of Fuel Oil Used Average Characteristics	Cooling System (Open or Closed) (Raw or Softened)	Fuel Oil	Lub. Oil	Attendance	Supplies	Repairs	Total
1	2	4,500	3,000	21,189,100	16,444	3,200	76.4	86.0	94.0	24	24	4.75	71.5	0.67	0.000225	15,500	3	15° B.	C S	4.08	0.16	0.84	0.11	0.64	5.83
2	3	3,450	2,400	14,853,310	20,010	2,300	73.6	96.5	76.5	24	8	3.43	61.0	0.0454	0.000560	8,250	3	26° B.	C R	2.78	0.34	0.99	0.15	0.56	4.81
3	4	3,125	2,100	3,391,000	11,670	1,150	34.0	51.0	34.4	24	24	5.20	49.0	0.6345	0.000650	16,650	2	22°-28° B.	C R	4.35	0.32	4.02	1.47	1.81	11.97
4	5	2,300	1,535	5,252,046	17,900	800	38.0	....	....	24	24	5.00	54.0	0.689	0.001040	7,350	3	26°-28° M.	O S	4.84	0.56	1.92	1.45	....	8.77
5	3	2,160	1,440	401,130	.....	.....	.....	....	....	24	24	5.71	65.9	1.2	0.003500	400	.	.....	C S	9.25	1.32	2.44	0.99	.....	14.00
6	4	2,100	1,400	1,470,500	.....	.....	.....	....	....	24	24	5.84	68.5	0.78	0.001210	1,100	.	.....	C S	6.10	0.79	2.80	2.07	.....	11.86
7	4	1,850	1,230	2,886,200	18,807	1,000	33.0	50.0	53.5	24	24	6.10	42.0	0.682	0.001420	7,000	2	36°-40° B.	C S	5.37	0.80	3.22	1.40	1.06	11.85
8	4	1,560	1,040	1,998,200	11,100	600	38.5	50.6	44.0	24	24	3.00	58.0	0.7	0.001220	7,000	2	24° G	O S	3.00	0.71	3.13	0.50	2.04	9.38
9	2	1,500	1,000	4,831,500	8,000	1,200	46.0	....	....	24	10	3.30	80.5	0.64	0.000360	6,800	1	23°-27° B.	O R	2.82	0.29	2.18	0.038	0.68	6.01
10	2	1,500	1,000	3,001,780	8,071	.....	74.5	....	46.0	24	11	2.92	56.0	0.74	0.001820	2,200	2	26° B.	O R	2.97	0.98	2.48	0.18	1.40	8.01
11	2	1,350	900	1,503,830	4,198	475	36.6	85.0	22.4	24	4	2.96	25.6	0.651	0.001340	2,800	2	26° B.	O R	2.61	0.34	3.16	0.21	1.00	7.32
12	3	1,350	900	3,078,900	14,924	435	81.5	69.0	57.0	24	..	4.00	27.0	1.288	0.000670	9,750	2	Gas Oil	O S	4.81	0.18	10.1	1.11	0.21	16.40
13	3	1,350	810	1,655,400	9,586	450	41.9	69.0	34.0	24	24	5.80	49.0	0.62	0.001070	6,600	3	Distillate	O R	6.24	0.52	5.74	1.52	0.17	17.20
14	2	1,215	810	1,869,500	8,000	340	39.2	36.0	91.5	24	..	6.80	59.5	1.0	0.000900	4,600	3	24°-26° B.	O R	9.04	0.534	4.96	0.00	0.00	14.50
15	2	1,200	800	1,200,000	8,640	550	25.0	35.0	49.0	24	24	5.25	37.5	0.78	0.001670	5,200	.	24° G.	C R	5.7	0.625	9.2	....	1.15	16.70
16	3	1,200	800	1,203,000	.....	.....	.....	....	....	24	24	5.69	53.6	.....	0.001780	750	.	.....	C S	6.72	0.91	3.8	2.92	.....	14.35
17	2	1,200	800	896,200	.....	.....	.....	....	....	24	24	5.93	60.5	.....	0.001000	1,350	.	.....	C S	8.42	0.585	6.18	2.22	.....	17.41
18	2	1,050	700	1,075,658	.....	.....	.....	....	....	24	24	5.55	69.2	.....	0.001610	850	.	.....	C S	6.1	1.03	2.55	0.96	.....	10.64
19	2	700	460	270,140	.....	.....	.....	....	....	24	24	5.68	66.1	.....	0.001940	700	.	.....	C S	8.25	1.52	8.44	9.85	.....	28.0
20	2	600	400	360,000	3,200	145	28.3	56.2	18.3	24	4	6.40	63.0	0.68	0.000420	5,800	2	32°-36° G. O.	C R	7.4	0.58	6.58	0.106	0.093	14.76
21	2	600	400	693,425	8,760	200	40.0	39.5	50.0	24	..	2.44	53.2	1.12	0.002710	2,700	2	Gas Oil	O S	3.83	1.45	18.0	1.20	2.46	27.0
22	2	600	400	720,000	8,640	210	39.1	41.7	49.3	24	24	5.00	37.5	0.95	0.001800	4,000	.	22° G.	C R	5.55	0.675	6.66	.....	1.00	13.9
23	2	600	400	900,000	8,640	230	45.0	52.1	49.3	24	24	5.00	37.5	0.75	0.001450	4,000	.	24° G.	C R	4.44	0.541	8.66	0.8	.....	14.4
24	2	400	265	622,000	11,282	320	22.2	41.0	64.3	24	3	4.00	62.0	0.82	0.00960	4,700	3	32°-36° G. O.	.. R	4.40	0.6	6.80	....	.....	12.76
25	1	240	240	35,200	.....	.....	.....	....	....	24	..	5.72	....	.....	0.00400	3,200	.	.....	C R	7.6	.....	9.25	0.96	.....	119.0
26	1	360	220	270,000	2,400	.....	.....	....	27.4	12.5	..	5.00	46.0	0.71	0.001350	2,200	1	26°-28° B.	O R	4.71	0.63	8.45	0.00	1.02	14.8
27	2	315	210	187,231	.....	.....	.....	....	....	24	..	6.74	80.0	.....	0.002890	500	.	.....	C R	13.8	1.99	11.6	13.6	.....	42.0

Cost of Gas—

The average cost of gas for 200-hp. load with a 35 per cent annual load factor in southern California, averages around 30c a thousand for 1,000 B.t.u. gas. A typical gas engine proposal is available from the committee chairman. The figures given in last year's report on agricultural pumping and natural gas have not been changed in any way, but due to the sales method adopted, namely selling engines installed for a small down payment which does not exceed the cost of an electric motor, together with the offer of accepting the balance out of the estimated savings, has been the means of hoodwinking even hardheaded business men into the belief that they have no investment and that no extra attention over that required by electric drive is necessary. The first year of operation is of course cheapest for the gas engine. The plants that have been in only one year or less, are those that are highly advertised. The committee has obtained a good refutation of this time payment plan and we would particularly impress upon all power salesmen the fact that the collections for the engine are not made by the gas engine company but by some cold blooded finance company who negotiates the paper for the engine company.

An important report on the gas engine business in southern California has been collected, consisting of some 26 pages, and this has already been distributed to members of various companies who have requested it. The main point of interest is that the gas engine people claim 600,000 hp. for natural gas engines in southern California, divided as follows:

Oil Industry	500,000
Industrial	25,000
Agriculture	75,000
Total Horsepower	600,000

In confirmation of the prediction that we may expect more and more competition in natural gas we would refer to the following data compiled from the Los Angeles *Times*, Nov. 9, 1929, which says, "79,000,000,000 cubic feet of gas were wasted in the air during the year 1928." The potential value of this gas, assuming its heat content at 1,000 B.t.u., and 12½ cu.ft. of b.hp.-hr. on an engine, is 6,300,000 b.hp.-hr. or 4,700,000,000 kw-hr.

Referring to the paper by George L. Reed read before the Oil and Gas Power Division of the American Society of Mechanical Engineers, there are 150,000 engines of all types engaged in the oil industry throughout the United States. These are being augmented at the rate of 15,000 a year, and it is estimated the production end of the oil industry is spending $30,000,000 annually for these engines.

Total horsepower—2,205,000, which is divided as follows:
1,780,000 hp. single cylinder gas engines
252,250 hp. Diesel engines
178,750 hp. steam engines

Insurance of Gas Engines in the Oil Fields—

Insurance of gas engines is a serious problem to the operator and one that should not be overlooked. Consultation with insurance men will reveal that rates on gas engines are from two to three times higher than for electric motors of a corresponding rating. This fact is seldom brought to the attention of a prospective engine purchaser.

Conclusion

Some idea of the comprehensive character of the work of the general power company may be obtained from the information included in this brief report. As was pointed out at the beginning of this report, copies of the complete studies of the committee may be obtained by addressing the chairman of the committee or the secretary of the association.

Engineering Section[1]

ACCIDENT PREVENTION COMMITTEE REPORT[2]

The accident prevention committee this year presents no formal papers but merely a summary of discussions of subjects of common interest which were taken up at the various committee meetings. Among these are poison oak, snake bite, standardization of first aid practice, safety clothing, mechanical resuscitation devices, rubber glove testing and educational methods.

THE work of the accident prevention committee this year was carried out along slightly different lines than formerly, in that little attempt was made for preparation of papers on specific subjects. With a small committee personnel it was thought that greater mutual benefit would result from meetings at which the many interesting points, common hazards, and new ideas that are continually arising with the different individual members could be generally discussed.

This proved to be quite a prolific field of endeavor and many things of value were developed from such discussions. Our membership, made up as it is of one or two men from each coast company, affords a most favorable opportunity of bringing out different experiences from the entire field.

Many specific matters dealing with causes of injury and accident and the methods for overcoming them were discussed and in some cases, settled quite satisfactorily. In others, research work is still being carried on.

Poison Oak

Some member companies have had a great deal of trouble with this wide-spread and prevalent cause of disability and a great deal of research and experiment work has been conducted for two years. Mr. Buswell prepared the original paper on this subject early in 1929. From this report and later discoveries, we find no less than nine substances alleged to provide immunity and about a dozen additional substances suggested for cures. Most of these have been tried to some extent. Results seem to indicate that as a preventative, a commercial cream known as "Boon" appears to work very well and is easily stored and applied. Ferric chloride, in a 5 per cent solution of equal parts of alcohol and water was also found to be a good preventative. As a cure or remedy, powdered quinine is found to be quite effective, while a newly developed commercial remedy known as "Cala Poison Oak Remedy" is thought to be the last word in some localities. The fact that doctors can not find a specific, or even a fairly good treatment in many cases, has led to this present study. Although it is still in progress, we believe we are having better success with poison oak than formerly.

Snake Bite

This is also a hazard of no mean proportions in some districts and one that also seems to have many treatments. The result of our work was to discard rather completely the old method of using potassium permangenate as a remedy after cutting the wound open. The most advanced experience tends to prove that simple manual methods of cutting, bleeding and sucking the wound are quite efficient first aids, while as a remedy the new "North American Snake Bite Serum" is strongly recommended as surpassing all others.

Standard First Aid Practice and Manual

Different companies have experienced a great deal of trouble and expense because of the difference in methods of teaching and training first aid methods. This is largely due to the different manuals or text books printed on the subject. We have initiated efforts to have a national standard first aid manual written and adopted so that a man receiving training from one company will, upon going with other concerns in other localities, not find that he has to learn it all over again because of a little difference in text books. This would be a time, trouble and money saver to all industrial concerns.

Insull Medal Awards

During the past year, the National Electric Light Association has awarded the Insull Medal to four men in our district. These men are: C. E. Seymour, Southern Sierras Power Company, E. M. Wiseman, Los Angeles Gas and Electric Corporation, E. W. Horsley, Southern California Edison Company, and W. T. Buzzell, Southern Sierras Power Company. These medals each mean a successful resuscitation from electric shock, and their award demonstrates quite clearly the value of resuscitation and first aid training. There have also been other successful cases in our district where the medal was not applied for.

Safety Clothing

There was a general exchange of ideas and experiences as to the value and efficiency of additional safety clothing, especially rubber protective sleeves and safety shoes.

Mechanical Resuscitation Devices

Several newly developed machines and devices for the application of artificial respiration came under the surveillance of the committee, but after investigation and trial, the committee went on record as not being in favor of them.

Testing Rubber Gloves

The testing of rubber gloves is a question that again holds national attention. Our committee is likewise conducting experiments and tests and getting information as to the best method of testing.

Educational Methods

The educational factor in accident prevention has for some time been recognized as the largest and most important phase of the entire question. This means both education of the workman to a realization of his own personal responsibili-

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[1] Executive Committee: F. R. George, Pacific Gas and Electric Company, chairman. R. H. Halpenny, Southern Sierras Power Company, vice-chairman.
Coast Counties Gas and Electric Company: F. S. Thomas.
General Electric Company: A. G. Jones.
Great Western Power Company: H. K. Fox.
Los Angeles Gas and Electric Corporation: F. R. Knight, E. R. Northmore.
Pacific Gas and Electric Company: H. H. Buell, R. R. Cowles, H. T. Sutcliffe.
San Diego Consolidated Gas & Electric Company: K. B. Ayres.
San Joaquin Light & Power Corporation: C. E. Schnell.
Southern California Edison Company: R. G. Boyles, L. L. Conrad, N. B. Hinson, R. M. Peabody.
Southern Sierras Power Company: E. Y. Porter.
Westinghouse Electric & Manufacturing Company: A. W. Copley.

[2] J. R. Rowe, Los Angeles Gas and Electric Corporation, chairman. S. C. Dickinson, Pacific Gas and Electric Company, vice-chairman.
Coast Counties Gas & Electric Company: F. S. Thomas.
Los Angeles Bureau of Power & Light: W. L. Smith.
Los Angeles Gas and Electric Corporation: Vernon Taylor.
Pacific Gas and Electric Company: S. G. Olsen.
San Diego Consolidated Gas & Electric Company: W. E. Richmond.
San Joaquin Light & Power Corporation: J. M. Buswell.
Southern California Edison Company: D. G. Macey, Howard Miller.
Southern Sierras Power Company: J. S. Allan, M. S. Slaughter.
Westinghouse Electric & Manufacturing Company: David Hall.

ties, as well as the foreman into realizing the important part that he plays. Heinrich of the Traveler's Insurance Company has just found by an analysis that out of 10,000 accidents, 88 per cent of them are due to management and faulty supervision. This means that executive and foreman must be taught that they are mainly responsible for industrial injuries due to lack of interest, non-application of recognized safety methods and improper supervision. Toward this end, our committee is bending its present and future efforts.

Something new was introduced along this line recently in connection with joint sessions of the accident prevention committee and other committees. Short playlets, films and talks will be presented that will be interesting as well as instructive. They will convey the idea of the importance of safety work to the men in these other committees who are in the main part engineers, supervisors, foremen and others who could be of great help in putting across our efforts in reducing industrial accidents.

ELECTRICAL APPARATUS COMMITTEE REPORTS[2]

*Condensers**

Operating experience with synchronous condensers forms the basis of the following report, with consideration given to certain weaknesses in design which have manifested themselves after the equipment has been in service over a period of time. Methods of protection against electrical breakdown which have been used are discussed as well.

The relative advantage of various types of cooling systems are touched upon and photos of the new hydrogen cooled outdoor units are included, together with statements from the utilities operating these units, covering their experience and results obtained to date.

Among the subjects covered are:

1. Bearings—

- *(a) Oil pressure on bearings*
- *(b) Maintenance recommendation*
- *(c) Oil leaks*

2. Rotors—

- *(a) Field pole winding construction and support*
- *(b) Short circuited field turns*
- *(c) Grounded field coils*
- *(d) Ground detectors for field circuits*
- *(e) Collector ring trouble*
- *(f) Amortisseur windings*

3. Protection—

4. Cooling Systems—

- *(a) Open air circulation*
- *(b) Partially closed systems*
- *(c) Totally enclosed systems*
- *(d) Hydrogen enclosed systems*

Bearings

Oil Pressure—

ON THE subject of bearings, one company representative reports that some trouble was experienced in starting a 5,000-kva. frequency changer as an induction motor.

The bearings were drilled and tapped at the bottom and piped for forced lubrication by means of a manually operated

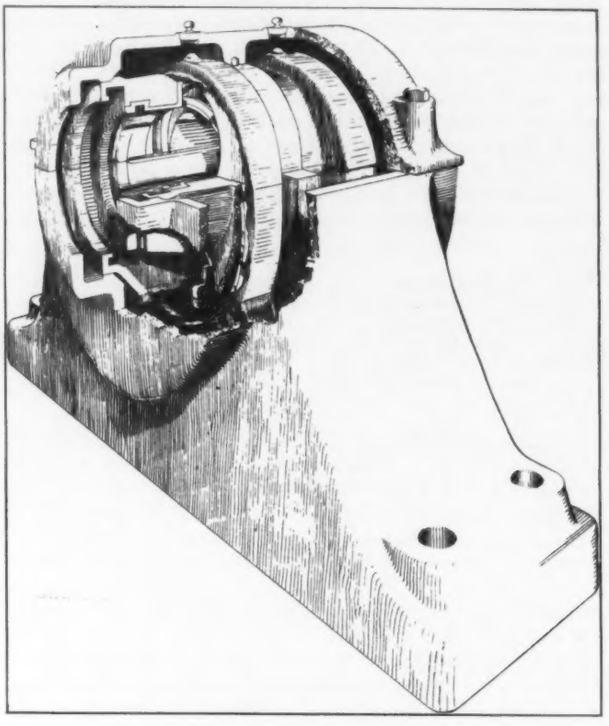

Fig. 1. Leakproof bearing.

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[2] H. L. Sampson, Southern California Edison Company, chairman. R. D. Likely, San Joaquin Light & Power Corporation, vice-chairman.

Allis Chalmers Manufacturing Company: J. G. Corrin.

Farnham & Cunningham: R. E. Cunningham.

Garland Affolter Engineering Company: P. H. Affolter.

General Electric Company: A. Fulton, H. E. Fuqua, O. A. Gustafson, R. F. Monges, G. P. Mackenzie, J. C. Porter, J. P. Price, J. S. Spurck, W. C. Smith, H. C. Stanley.

Great Western Power Company: C. F. Benham, G. K. Morrison, A. Scott.

Ingalls, Inc., C. E.: C. E. Ingalls.

Kelman E & M Company: E. K. Sadler.

Los Angeles Bureau of Power & Light: J. C. Albert, H. H. Cox, C. P. Garman, O. W. Holden.

Los Angeles Gas and Electric Corporation. G. M. Babcock, L. A. Buese, C. B. Judson, J. G. Rollow.

Pacific Electric Manufacturing Company: E. F. Sixtus, Roy Wilkins.

Pacific Gas and Electric Company: F. S. Benson, E. A. Crellin, H. G. Keesling, H. A. Laidlaw, H. S. Lane, W. D. Skinner, C. W. Smith, H. T. Sutcliffe.

San Diego Consolidated Gas & Electric Company: K. B. Ayres, A. S. Glasgow, D. G. Kelly.

San Francisco Engineering Department: P. J. Ost.

San Joaquin Light & Power Corporation: E. J. Crawford, R. C. Denny, P. C. McCorkle, E. W. Otto, C. E. Schnell, D. D. Smalley.

Southern California Edison Company: T. J. Lovell, R. B. Pollock, E. W. Rockwell, A. P. Sessions, E. R. Stauffacher, C. W. White.

Southern Sierras Power Company: Frank Ayres, M. L. Baden, Francis Curtis, H. J. Schomberg.

Thomas Co., H. M.: H. M. Thomas.

U. S. Motors Company: T. G. Myers.

Utilities Equipment Corporation: S. P. Russell.

Westinghouse Electric & Manufacturing Company: J. E. Bridges, A. W. Copley, A. H. Enger, P. B. Garrett, W. F. Grimes, D. Hall, R. A. Hopkins, W. P. L'Hommedieu, C. C. Potts, R. C. Stackhouse, H. S. Warren, W. L. Winter.

* Report of subcommittee on condensers, electrical apparatus committee, Engineering Section. A. P. Sessions, chairman. B. A. Anderson, G. M. Babcock, A. W. Copley, H. H. Cox, R. C. Denny, H. E. Fuqua, O. A. Gustafson, D. J. Kelly, R. B. Pollock, C. W. Smith, A. Scott.

pump, which forces a film of oil between the shaft and the bearings. This decreased the starting current considerably, and decreased the starting time 60 per cent.

Maintenance Recommendation—

One company reports that it has been their standard practice with large machines to install a dial-type thermometer and pressure gage on each large bearing. By means of checking the recorded temperature and pressure readings over a period of time it is possible to anticipate when it is necessary to work on the bearings some time in advance, so that emergency bearing trouble is practically eliminated.

Oil Leaks—

Concerning the improving of conditions in bearings which do not retain oil, one company reports that fair success has been attained in a number of 35,000-kva. condensers by installing a special fan on the shaft inside of the outer shell. The fan consists of a thin metal band which clamps onto the shaft, upon which short turbine-shaped blades are mounted, which tend to draw air into the bearing along the shaft and out at the top of the bearings. This counteracts any tendency for oil or oil vapor to work out of the bearing along the shaft and be drawn into the machine where it serves as a dirt collector on the rotor and windings.

Another case of oil and oil vapor leakage along the shaft has been cured completely by the installation of an air seal at each end of the bearing.

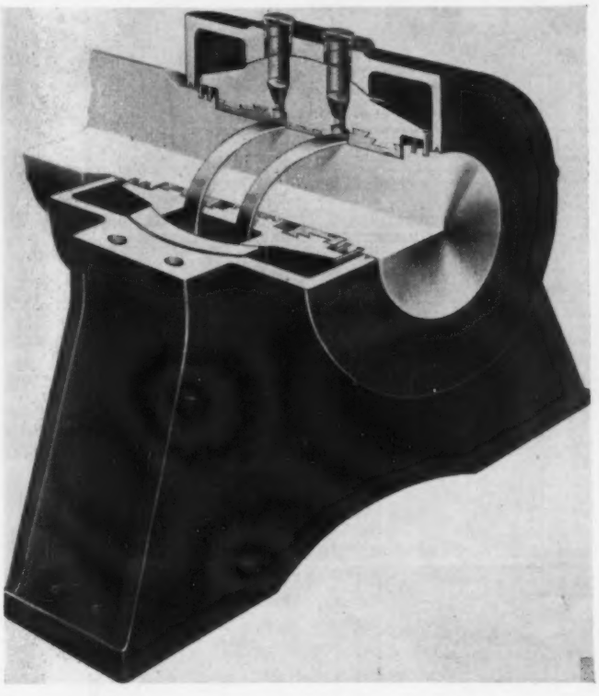

Fig. 2. Pedestal and bearing to eliminate oil leakage. Oil vapor from ring space cannot reach opening where shaft passes through pedestal.

This particular machine is a 15,000-kva. condenser which takes air from outside the building, through an intake pit, and delivers the exhaust air through a discharge duct in the roof of the building.

The continuous passage of air through the machine causes an air pressure in the discharge duct slightly greater than the air pressure in the room. A hollow annular metal ring was attached to each end of the bearing shell, and connected with 1¼-in. pipe to the discharge air duct from the condenser. Thus a continuous stream of air is delivered to each annular ring at a gentle pressure. This establishes an air seal which not only neutralizes any possible suction which might draw vapor from the bearing, but supplies a gentle back pressure tending to prevent oil or vapor from leaving the bearing.

Two of the leading manufacturers of electrical machinery have reported on the subject of improved design of new bearings to eliminate the leakage of oil and oil vapor from the bearings.

Both designs have embodied the same changes and each appears to be entirely satisfactory. The changes in design are well expressed in one of the reports as follows:

> The problem of preventing oil leaks from bearings is largely one of preventing suction on the outside of the bearing housing, tending to draw oil vapor from the bearing itself. The accompanying sketch shows the present line of bearings for synchronous condensers manufactured by us, and in which we have carried out our most recent ideas for the prevention of oil leaks. The oil ring guard has been made a part of the casting and extends below the oil level in order to minimize splashing and formation of oil vapor.
>
> This guard is babbitted inside so that the sides of the oil ring will bear on babbitt rather than cast iron. Grooves have been provided in the sides of this oil ring guard which collect the spray or oil discharge from the sides of the ring and carry it back into the bearing at the split, rather than allowing this oil to be carried around by the oil ring and back into the reservoir.
>
> A drain has been provided at each end of the bearing shell for collecting the oil which drains from the circular oil grooves at the end and also the oil which runs out at the ends of the bearings and carries it back into the oil reservoir at a point below normal oil level.
>
> The top half of the bearing has also been babbitted in order to reduce splashing and formation of oil vapor.
>
> The keys which secure the two halves of the bearing shell, together also serve to prevent oil leaking out between the halves of the bearing at the split.
>
> In order to prevent the escape of oil vapor through sight holes for oil rings, tapered reamed plugs have been provided in the housings, and steel balls with machined seats in the bearings. The tapered plug and ball are fastened together by means of a chain to facilitate removal and replacement of the ball.
>
> At each end of the bearing housing, an air bypass chamber has been provided to reduce the suction tendencies to draw oil vapor from the bearings. A pipe connection is provided to this chamber which prevents the formation of a vacuum or suction. Brass plates with a running clearance around the shaft are also provided at each end of the bearing.

Field Pole Winding Construction and Support—

> In one case the field coil shims and wedges worked out and struck the stator winding, damaging the coil insulation on a number of coils. All field coils were rewedged. In another case the field connections opened, due to poor workmanship at joints.

In still another case serious unbalance developed when the bottom turns on two adjacent field coils arced over, short-circuiting the complete windings of two adjacent field poles. This was caused by the loss of insulating liners for wedge blocks between the field poles. The loss of magnetic pull unbalanced the rotor to such an extent that those present thought there was an earthquake. The machine was shaken sufficiently to break two dowels on one bearing pedestal and loosen bed plate from cement grouting.

The field pole windings were removed and a small portion of the width ground off at the bottom to increase clearance between coils, after which full length liners for wedges were clamped into place.

One company reports considerable trouble from field pole, winding collar mechanical breakdown, due to cemented portions breaking apart. This was on machines of large size. The wood collars would shrink. Fiber collars were tried with the same result; steel collars were tried but these only stood up from one month to one year.

Single piece Bakelite or Hercolite collars were tried and have been satisfactory for one and a half years.

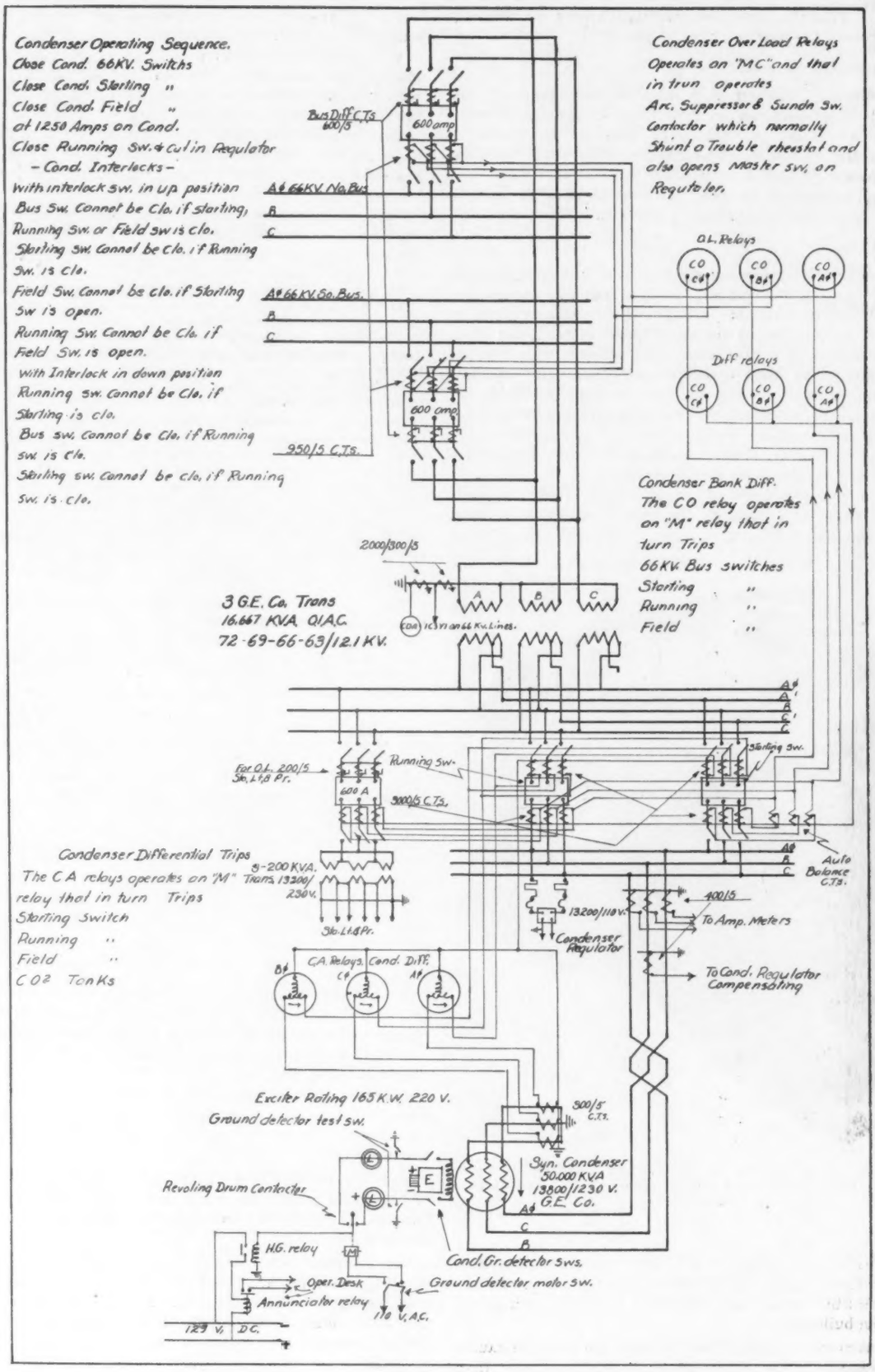

Fig. 3. Three-line wiring diagram, No. 3 condenser and equipment, Lighthipe substation, Southern California Edison Company.

Short-Circuited Field Turns—

Only one company reports any appreciable amount of trouble from short-circuited turns in field coils. This company has had numerous cases which have first made themselves known through vibration and unbalance. In some cases field coils were completely reinsulated with asbestos paper and mica. This has given perfectly satisfactory service for periods varying from six months to one year since these jobs were done.

One manufacturer reports as follows:

It has been the practice for many years to insulate the turns of strap-wound field coils by the use of strips of asbestos placed between the turns. These strips are soaked in shellac, and after they are placed in position, the field coil is put under pressure and heated so as to squeeze out the volatile matter and consolidate the coil into a solid mass.

Some trouble has been experienced on account of short circuits between the field turns, and this has resulted in the investigation of the asbestos insulation. A high grade of asbestos is now being used which is free from the minute metallic particles which were apparently the cause of past troubles. In some cases we now make the turn insulation in three layers, two of the layers being asbestos and the third layer being either paper or mica. With this construction the dielectric strength of the insulation is very greatly increased over that of the old method.

Grounded Field Coils—

One company reports some trouble from field coils becoming grounded. With the regular ground detecting lights and alarm relay, difficulty was experienced in determining a ground when the ground was on the field poles near the middle of the circuit, as the potential for the middle coils from ground is very low, consequently the special "flasher" ground detector which is described below, was developed.

Ground Detectors for Field Circuits—

The "flasher" ground detector has been in service for nearly a year on several large synchronous condensers with perfectly satisfactory results. It is so constructed that a sensitive ground relay tests, first one side and then the other side of the main field circuit, for ground induction once each minute. This changes the potential to ground for every point in the field circuit so that a ground at any location is sure to be indicated.

The wiring connections for this ground detector are shown on the accompanying wiring diagram for the Lighthipe 50,000-kva. condenser.

Collector Ring Trouble—

One company reports considerable trouble from the development of dark rough spots on condenser field collector rings. These spots are uniformly spaced the same distance apart as the brushes. With each revolution of the rotor sparking occurred under all brushes, which would continually grow worse until it was necessary to grind and polish the rings. The trouble was apparently aggravated by the fact that the brushes were equally spaced. There were six brushes on each ring. Three of the brush holders were reversed so that the uniformity of spacing was broken up into two groups of three brushes each. Since that time commutation between rings and brushes has steadily improved. Irregularity of spacing of brushes on collector rings has a decided advantage over uniform spacing.

One company reports as follows:

Considerable trouble has been experienced on a couple of rotaries with flashing over between a.c. rings and a.c. rings to ground.

The riser connections were originally bare; the connections from the rings to the risers were bare copper rods slipped through a

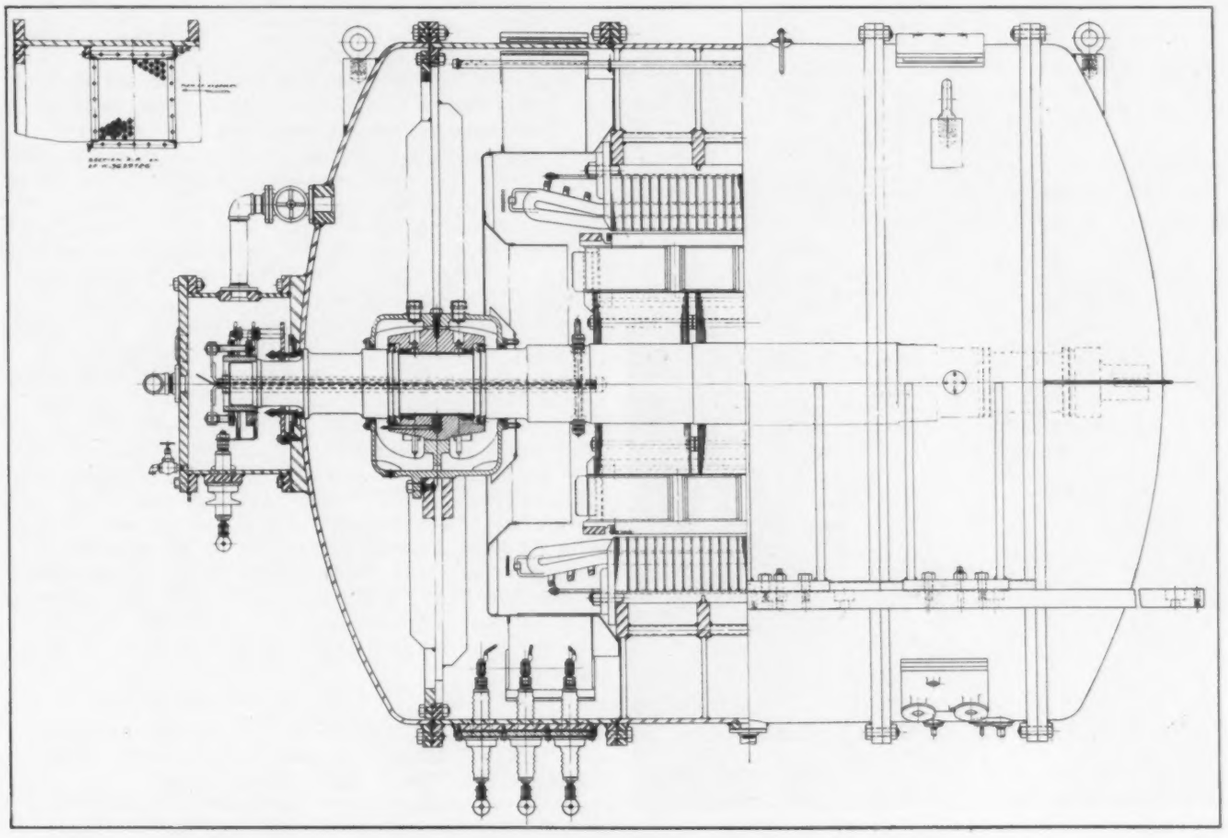

Fig. 4. 11,500-volt hydrogen-cooled outdoor synchronous condenser, longitudinal semi-section

Hercolite or Bakelite tube. The extension of the tube beyond the first ring was only ¾ in. The risers were so made that there was only about ⅝ in. clearance from the bare connection to the shaft. After the first flashovers, it was decided to tape up the risers. This was done with very good results for about a year, when flashovers began to occur again. The machine was blown out at regular intervals and wiped up but that still did not help matters much. During the last two flashovers to ground the shaft was badly pitted and bearings needed scraping.

We dismantled the machine and sent the armature to the shop. An inspection of the risers revealed that carbon dust had been blown in the crevices of the tape at the joint where the riser was soldered to the ring rod, causing a carbon path along the Bakelite tube which caused the flashover.

We then reconstructed the riser connection by soldering a straight pressed copper lug on the end of the ring rod, and turning the ring rod down to fit the lug.

The flat part of the lug was then bent up with a radius of about ¼ in., and the leaf copper riser was riveted and soldered to the flat part of the lug. This was the same as extending the ring rod about 1½ in. The Bakelite tube was made new and extended about 1½ in., or twice as far as the old job.

The riser was taped up, but lapped over the Bakelite tube only about ¼ in., leaving a good clean hard surface of the tube which could be wiped off and no place for carbon dust to hold.

All risers were painted with red paint. The shaft under the risers from the first ring to the spider was also taped and painted with red paint.

This job has been in since May, 1929, with no further trouble.

Amortisseur Windings—

One case of machine failure due to burned bars of amortisseur winding was reported for a 30,000-kva. condenser. The bar which caused the trouble burned off at the point of connection with the short-circuiting ring, during the starting period when the machine was practically up to full speed. As the bar burned loose from the ring, it was no longer mechanically supported, and being heated, was disastrously subject to centrifugal force, due to the speed of the machine. It swung outward and raked the windings of the stator, causing serious damage to the coils. Following this some of the brass bars were changed to copper and the method of connection to the short-circuiting ring improved.

Two cases of trouble with amortisseur windings on frequency changers were reported. In one case it was stated that "the amortisseur winding bars become crystallized at the point where the bars are connected to the short-circuiting ring, caused by excessive heating through poor starting conditions."

Frequency changers are subject to severe strains on the amortisseur windings during periods of system trouble in either of the two transmission systems to which the frequency changer is connected.

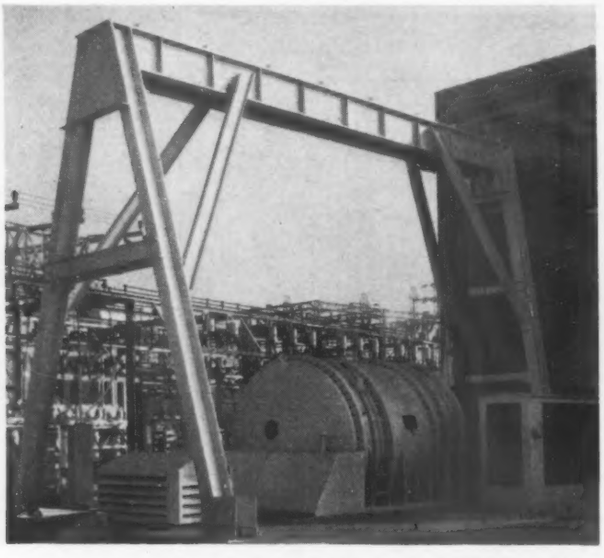

Fig. 5. Outdoor hydrogen-cooled 11,500-volt synchronous condenser, Appalachian Power Company, Charleston, West Virginia.

One company reports considerable trouble from this source, over a period of a number of years past. When first installed the bars were bolted to the short-circuiting ring with iron cap screws. Heating and cooling, together with the mechanical strains of operation increased the contact resistance between the bar and end ring, with the result that the cap screws were soon forced to carry starting currents as well as to support the bar mechanically. Under these conditions the cap screws melted down and burned off.

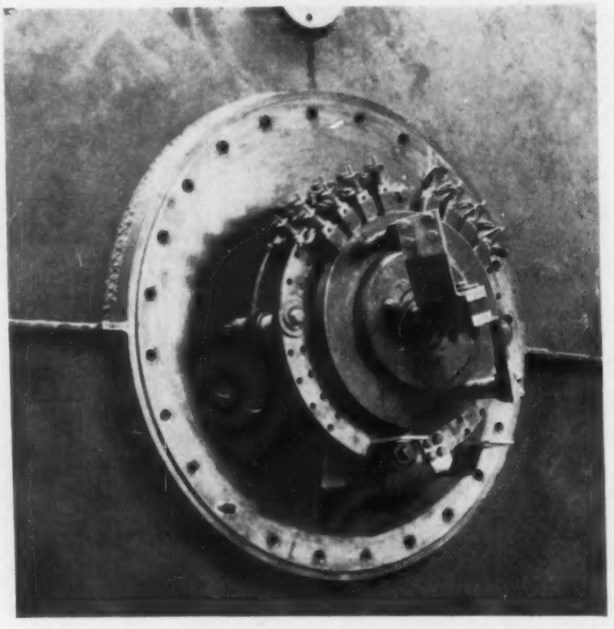

Fig. 6. Collector ring arrangement, with collector ring cover removed.

It was necessary to improve the contact between the bars and the end ring. This was attempted by installing on the bars on each pole piece, a copper segment having an "L" cross section. The bars were brazed to the copper angle segments on both ends and the copper segments then bolted to the end ring.

The bond between the bars and the angle segment, however, proved to be poor, and was replaced by silver solder. In addition to the regular brass bars which occupy the center section of each pole shoe, the outer copper bars (near the tip of each pole piece) were extended on through stirrups on the end ring, and silver soldered to semi-flexible strips which were bolted to the end ring on the outside. This construction was necessary in order to provide for the increased expansion of copper over brass. Recently some of the semi-flexible strips have broken, so they have all been replaced with a laminated flexible strip. This job, which embodies the addition of the separate copper segment for each pole piece, silver solder, and extra flexible connections for the copper bars, has been in service for some months with satisfactory results. It is believed that no further trouble will be experienced.

Protection

Complete differential protection of power transformer with special starting taps which serve synchronous condensers, is a more complex matter than the ordinary case, due to the fact that the ratio of transformation during starting is different from the ratio during the running period.

One company has adopted as standard the method of current transformer secondary connections shown in the accompanying wiring diagram of the Lighthipe 50,000-kva. condenser.

In this connection the current transformers in the starting and running leads are chosen with such a ratio as to produce the same secondary current as that produced by the current transformers on the high side of the power transformers.

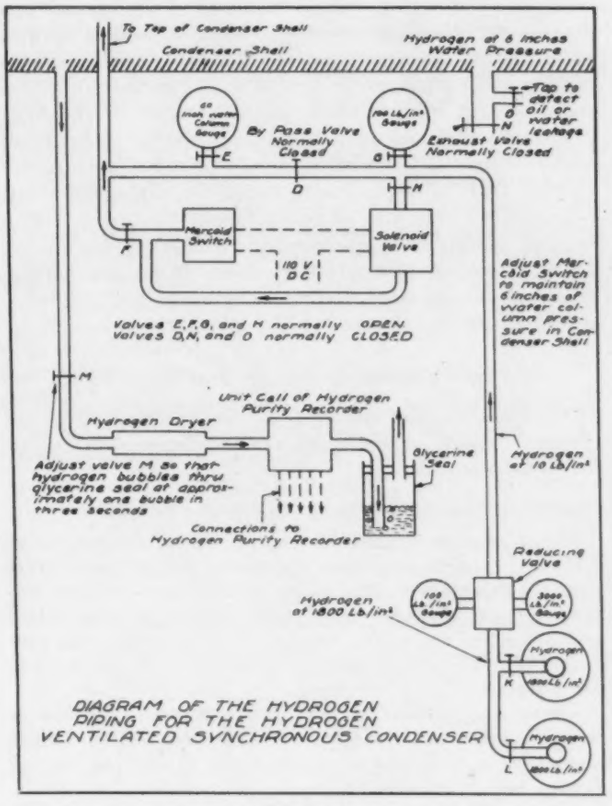
To Top of Condenser Shell
Condenser Shell
Hydrogen at 6 inches Water Pressure
Tap to detect Oil or Water leakage
By Pass Valve Normally Closed
Exhaust Valve Normally Closed
Mercoid Switch
Solenoid Valve
110 V DC
Adjust Mercoid Switch to maintain 6 inches of water column pressure in Condenser Shell
Valves E,F,G, and H normally OPEN
Valves D,N, and O normally CLOSED
Unit Cell of Hydrogen Purity Recorder
Hydrogen Dryer
Glycerine Seal
Hydrogen at 10 Lb/in²
Adjust valve M so that hydrogen bubbles thru glycerine seal at approximately one bubble in three seconds
Connections to Hydrogen Purity Recorder
Reducing Valve
Hydrogen at 1800 Lb/in²
DIAGRAM OF THE HYDROGEN PIPING FOR THE HYDROGEN VENTILATED SYNCHRONOUS CONDENSER

Fig. 7. Diagram of the hydrogen piping for the hydrogen ventilated synchronous condenser.

The secondaries for the current transformers in the starting and running leads are paralleled, and carried to the differential relays, the impedance in the circuit of the current transformers which are not carrying current is great enough so that practically no current passes through this parallel path, hence the differential balance is maintained whether the machine is on the starting or running tap.

The attached wiring diagram shows the manner in which the current transformer secondaries from the starting and running circuits are paralleled so as automatically to balance out the starting current during the starting period.

This circuit is practically fool-proof from the operator's point of view due to its automatic compensation, and does permit complete differential protection of transformers, switches and intermediate connections as well as for the condenser itself.

Cooling Systems

Open Circulation Systems—

Relative to special means of cooling for machines with open circulating systems, where the machine takes air from the room and delivers it again to the same room, one company reports an installation of a 2,000-kva. condenser which ran at such a high temperature that only partial loads could be carried in the summer time.

A large opening was cut in the roof, over which a box covering was installed and through the wall of this a 36-in. 5-hp. exhaust fan was installed to draw air from the room and deliver it to the outside air. The installation was probably not quite as effective as a duct system would have been, but the temperature of the room was lowered sufficiently to permit carrying practically full load on the machine.

Partially Closed System—

There seems to be a wide variation in the practices of the various California companies concerning the use of partially enclosed cooling systems. Some take the air from the outside at the ground line and deliver it through the roof or high on a side wall, others take air from the room and deliver it through the wall or roof. Still others take air from the room and deliver it downward into a pit and thence to the outside at the ground line. One company reports the extensive use of air washers on intake air ducts, with satisfactory results; another company reports the accumulation of a great deal of alkali on the windings of the machine due to the use of an air washer. Still another company, which has over 450,000 kva. of condensers on its system, does not have a single air washer installed on any of the condensers.

Totally Enclosed Systems—

One company has several large condensers installed which have totally enclosed air circulating systems. They report a very great deal of satisfaction with this method of cooling. Several advantages are claimed, all of which seem to be well worth while.

Maintenance cost of annual overhaul is much reduced because of cleanliness of the machine. Cooling is kept at a continually higher efficiency due to continued cleanliness, hence operating temperatures are kept more nearly uniform over a long period of operation between overhauling periods. Opportunity is afforded for ideal conditions for the use of CO_2 gas for fire fighting equipment.

Hydrogen Enclosed Systems—

Although there are no hydrogen filled machines now in operation on the Pacific Coast, there are some machines now

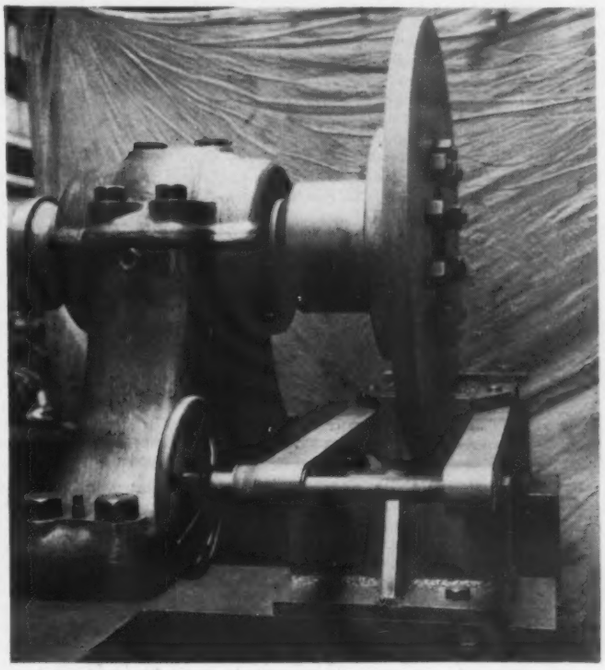

Fig. 8. Installation of a special hand brake for bringing machine quickly to rest.

on order which will be in operation within the next few months. Much interest has been shown in these types of machines, so that a number of pictures of Eastern installations and a hydrogen control diagram are shown in the accompanying illustrations.

As a matter of interest in this connection a letter from Philip Sporn, electrical engineer, American Gas and Electric Company, New York, is given as follows:

20,000-Kva. Hydrogen Cooled Synchronous Condenser—Turner Substation

Description—

The synchronous condenser installed at the Turner substation of the Appalachian Electric Power Company near Charleston, W. Va., is rated 20,000 kva., 11,500 volts, 60 cycles, 900 r.p.m., type ATI, and was built by the General Electric Company. The above rating is obtained by using for the cooling medium hydrogen gas at a pressure of about 0.3 lb. per inch above atmospheric pressure. The gas in turn is cooled by means of cooling coils in the condenser shell, in conjunction with necessary pumps and a spray pond located nearby. The machine is installed outdoors with a large pit underneath in which are located oil pumps, water pumps, hydrogen supply tanks, and necessary instruments and accessories for controlling the hydrogen. A 100-kw. motor generator exciter set is located in the adjacent control building.

Preliminary Tests—

The installation of the machine was completed in December, 1928, and at that time it was decided to run various tests to demonstrate the cooling qualities of hydrogen gas. These tests indicated that the capacity of the machine was increased about 33 per cent when using hydrogen instead of air as a cooling medium, while the losses remained approximately unchanged. The capacity could be still further increased by raising the pressure of the hydrogen gas, but normal operating pressure is maintained at 0.3 lb. per sq.in. above atmospheric.

Operation—

The machine has been running continually for the past year, except for a few short shutdowns made arbitrarily for various reasons. No trouble of any consequence has been experienced. The machine has been operating with voltage regulator control, the load varying between 20,000 kva. leading power factor and 12,000 kva. lagging. The condenser has not been opened up during this time.

Hydrogen Gas Consumption—

The pressure of the hydrogen gas is automatically maintained at about 7-in. of water above atmospheric so that any leakage will be outward and thus prevent any possibility of air getting into the machine. At this low pressure the leakage is very slight. The purity indicator equipment is such that a continuous drain of about 5 cu.ft. of gas per day is taken from the machine. During the past year the hydrogen consumption has averaged about 50 cu.ft. per week. This represents a cost of about 60 cents a week. On future designs the sampling gas for the purity indicator will be returned to the machine so that the gas consumption will be negligible. The purity of the hydrogen purchased is 99.5 per cent and the purity indicator for the gas in the machine now shows about the same figure.

Maintenance—

The bearings are included in the gas-tight shell of the machine, which makes them somewhat inaccessible. However, in the hydrogen atmosphere, the oil should retain its lubricating qualities for an unusually long period. In fact it has not been necessary to replace the oil originally put in the bearings a year ago. The oil pressure starting pump is used for changing oil in the bearings when required. Thermometers with alarms will immediately indicate trouble with the bearings, and opportunity for inspection is supplied by two manholes, one at each end of the machine.

The collector rings are also ventilated with hydrogen gas but are located in a small compartment separate from the main shell so that the brushes and rings can be inspected or replaced with very little trouble and with only a slight loss of hydrogen.

The elimination of moisture and dirt from the interior and the removal of the damaging effect of corona upon the insulation creates a condition whereby very little, if any, maintenance should be required over long periods of time. However, as a matter of interest, we are planning to inspect the interior of the machine sometime this month. As we have every reason to expect all parts will be in satisfactory condition, we do not plan again to open the condenser until 1935, unless some unusual occurrence should make it advisable.

*Control Equipment and Layouts**

Activities of the subcommittee on control equipment and layouts have been directed toward the study of equipment which has a very vital part in every electrical station of whatever size but which in the past has been considered only incidental to the functioning of some other electrical apparatus.

When we consider stations made up of the various and diverse electrical apparatus of present day usage such as prime mover equipment, generators, motors, synchronous condensers, switchgear, relays, etc., the correct functioning of which for normal operation as well as for fault protection is based upon the proper design, installation and functioning of control equipments, the importance of this topic is more easily visualized and understood.

It has been the aim of this subcommittee to develop a resume of the best practices of utilities of the Pacific Coast Electrical Association in regard to design, installation and operation of control equipment. The following is submitted as the result of its efforts:

Types, Sources of Energy and Voltages

TYPES, sources of energy and voltages, naturally constitute a closely related group and are discussed as such by individual companies.

San Diego Consolidated Gas & Electric Company—

Direct current is used for control on all substations of 1,000 kva. capacity or greater and the more important smaller capacity substations. The source of this power in each station is from a 60-cell lead plate storage battery floated across the line and trickle charged by a suitable motor generator set. The normal battery voltage is 129 volts or 2.15 volts per cell.

Alternating current is used for control in the smaller capacity substations, the source of power being potential transformers from the incoming station lines, the control voltage being 120 volts.

Southern California Edison Company—

All circuits considered of sufficient importance to be equipped with switchboard control are also considered to rate the greater reliability of the d.c. type. However, on the many low voltage circuits which are equipped with automatic reclosing but without switchboard control, a.c. power for closing and also for the reclosing relays is used. On the relatively fewer circuits which are equipped with both reclosing and switchboard control, d.c. power is used for reclosing and in most cases for the relays also, although there are a few of this type of circuit using a.c. timing relays.

All installations having switchboard control use a battery as the source of energy with a motor-generator charger. In certain of the small stations where direct current is used for tripping but there is no switchboard control (and usually no attendant), a battery with a copper-oxide charger is used. There are many small stations in service using alternating current exclusively for tripping (tripping reactors or current transformers direct to trip coils) and for reclosing. However, the present tendency seems to be to use a battery and copper oxide charger even on the very small jobs. This type of charger seems to be operating quite satisfactorily although the question as to whether its tendency to overcharge will materially shorten the useful life of the battery remains to be

* Report of committee on control equipment and layouts, electrical apparatus committee, Engineering Section. C. E. Schnell, chairman. Frank Ayres, F. S. Benson, L. A. Buese, A. R. Enger, A. Fulton, C. P. Garman, D. J. Kelly, T. J. Lovell, G. K. Morrison, E. W. Otto, P. J. Ost.

settled, as at present there are no installations old enough to provide anything.

This company uses two d.c. voltages, 125 volts and 32 volts, and two a.c. voltages, 11 volts and 220 volts, 125 volts being used only on solenoid operated jobs, while 32 volts d.c. is used on motor operated breakers and on electrically controlled air operated breakers. This applies to stations where direct current is used for tripping only, as lower voltages are considered unreliable due to contact resistance, etc. Some years ago this company used 12 volts for tripping purposes but abandoned it after several instances of failure. In the majority of a.c. installations 220 volts is used, although there are a considerable number of "gravity" reclosing set-ups using 110 volts.

Southern Sierras Power Company—

At major stations 125 volts is the standard potential used for control batteries. Low voltage battery installations are made at stations of less importance where potential is required for tripping circuit breakers only. Motor generator sets floating on the line are standard for charging the 125-volt batteries, while rectifiers are used for low-voltage tripping batteries.

Los Angeles Gas and Electric Corporation—

In the past the practice has been to use both direct and alternating current for tripping and closing of circuit breakers. However, the tripping circuits using a.c. shunt coils gave considerable trouble due to failure to operate on low voltage at time of short circuits and this type of tripping circuit has been abandoned altogether.

In certain classes of service described later alternating current is used for closing with a series trip circuit, but in general the policy is to use direct current for both closing and tripping purposes. The fact that the territory served is a strictly metropolitan district with the smallest distribution station of 5,000 kva. capacity has greatly influenced the selection of types of control equipment. This has resulted in the use principally of 110 volts d.c. for both closing and tripping operations.

A very small amount of d.c. controlled apparatus is motor operated, but in general (about 97 per cent) is solenoid operated. Due to the mechanical simplicity we find the solenoid to be the most reliable and economical method. Its parts are few and very accessible and require practically no adjustment. All generating stations, switching stations and distribution stations are equipped with d.c. control.

Alternating current control is used in some of the small substations which are located on consumers' premises. The use of a.c. motor mechanisms is limited to approximately twelve of these stations with a primary voltage of 2,300 or 4,000 volts. The balance have hand operated breakers with series a.c. trip.

The preference for a.c. control over d.c. for this service is due to the elimination of the storage battery which would otherwise be required.

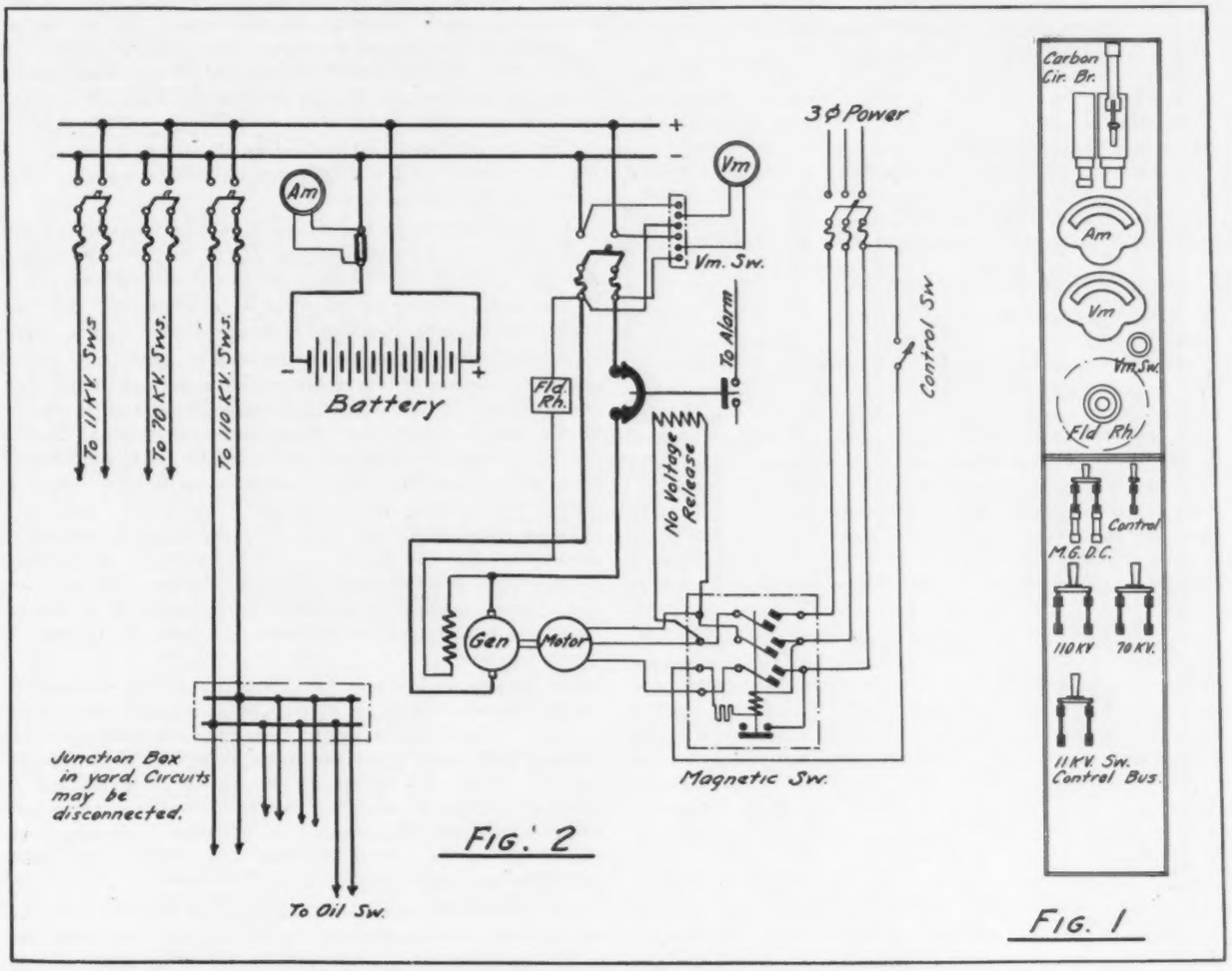

Fig. 1. Typical arrangement control panel—San Joaquin Light & Power Corporation. Fig. 2. Typical connections control equipment—San Joaquin Light & Power Corporation.

The sources of energy for d.c. controlled substations are as given in the following examples:

In generating stations the equipment consists of:
Two storage batteries, 240 or 300 amp.-hr. capacity.
Two 7-kw. motor generator sets.

In larger substations:
One storage battery, 140 or 240 amp.-hr. capacity.
One 7-kw. motor generator set.
One rectifying bulb trickle charger.

In smaller substations:
One storage battery, 80 amp.-hr. capacity.
One rectifying bulb trickle charger.

Where the normal load on the control system is below 10 amp., trouble has been experienced in trickle charging with motor generator sets. In these cases the battery is given a periodical freshening charge with the motor generator set. The motor generator sets are capable of closing any circuit breaker without the aid of the battery. Required battery capacity is based on the handling of the normal operation of a station for 24 hours without charging.

Only two d.c. voltages are used,—110 and 54 volts. The 54-volt control is confined to substations when the majority of the oil circuit breakers are hand operated. In the larger substations the control battery is centrally located and the wires carrying the closing circuit are of ample size and in some cases as many as six circuits are run.

Department of Water and Power, Los Angeles—

Control equipment on the Department's system comprising generating stations, receiving stations and distribution stations, is confined exclusively to the d.c. type which may be subdivided as follows:

For major generating, receiving and distribution stations, storage batteries with motor generator sets for charging.

For smaller plants and industrial substations, automobile type storage batteries with trickle charging equipment.

A voltage of 250 is standard for outdoor stations covering considerable area. For the larger types of indoor stations 125 volts is used, while for the smaller stations using automobile type batteries, a voltage of 48 or 24 is employed.

San Joaquin Light & Power Corporation—

This company commonly uses direct current for control purposes.

Energy is supplied by prime mover control generators at both hydraulic and steam power plants. Motor driven control generators are usually installed additional to these, but are not considered satisfactory alone, owing to loss of control energy when a system disturbance occurs or power is actually interrupted. At the steam plants a control battery is installed to avoid the necessity of keeping a boiler hot to supply steam to the turbine of the control generator when the plant is not generating. Provision is also made for an emergency feed from the exciter bus to the control bus where voltages permit.

Storage batteries of the lead plate type are universally used at substations for control purposes. Rectifiers are used to charge batteries from 12 volts to 40 volts inclusive and motor generator sets to charge batteries from 40 volts to 250 volts inclusive. No particular troubles have been experienced with either. The trickle charge method of operation is used with a cell voltage of 2.15 as the basis of charge. Motor driven generators are equipped with a no-voltage release to prevent discharging the battery when power to the motor is interrupted.

While no distinct line is drawn, at the older substations 12 volts or 18 volts is used in most cases where the capacity is 5,000 kva. and less. Where the capacity is in excess of this, 40 volts or 125 volts are used. In more recent designs 40 volts or 125 volts, usually the former, are used, for control purposes at all but small and less important stations. This trend to higher voltages is due to increased power requirements for the operation of circuit breakers as they increase in capacity and to the belief that higher control voltages are more reliable.

Power houses in general use 125 volts or 250 volts for control purposes.

Figs. 1 and 2 are typical of connections and switchboard arrangement for 20-cell lead plate batteries.

Pacific Gas and Electric Company—

There are two systems of control equipment in use on this system, namely, the d.c. type and the a.c. type.

Direct Current Equipment—The d.c. type is used in steam generating stations, hydro-electric generating stations, and important substations, where a reliable source of power is necessary. The type of equipment used is given in detail:

Steam generating plants generally require two complete systems, one for the control of main switching equipment, the other for the control of auxiliary equipment, such as automatic boiler devices, valves, and motor starting equipment.

The source of power for the switching equipment control generally consists of two motor generator sets and a 125-volt storage battery. The motor generator sets are arranged for trickle charging and their size is determined by the sum of the trickle charge load, control lamp load, and the emergency lamp load.

The control panels for these sets are located in the main switchboard room under the supervision of the operator.

The source of power for the auxiliary equipment generally consists of two steam turbine motor generator sets. These sets are normally operated by the motors. If the motor voltage drops low enough to decrease the speed approximately 15 per cent, a speed switch on the end of the shaft closes, which in turn opens the turbine throttle valve and the turbine picks up the load.

The size of unit is determined by the power necessary to close a number of the largest valves simultaneously. The sets generate 125 volts, d.c.

A remote control carbon circuit breaker is installed on the switchboard to give emergency power from turbo-motor-generator sets to the switching equipment control bus.

The switchboards and control equipment for the two turbine motor generator sets are located in the turbine room.

The control equipment for hydro-electric generating plants generally consists of two motor generator sets and a 125-volt storage battery. The motor generator sets are arranged to trickle charge the battery. Their size is determined by the sum of trickle charge power, control lamp load, and emergency lamp load. One motor generator set is installed as a spare.

Large substations, manually operated or semi-automatic, generally have two motor generator sets and a 125-volt storage battery. The motor generators in the older stations are designed to build up a voltage high enough to be able to "gas" the battery, but in all later stations, the battery is trickle charged.

The control equipment for automatic urban substations requires careful study, as it must be as nearly foolproof as possible. Storage batteries of 125 volts are installed in these stations and small motor generator sets trickle charge the battery. There are two motor generators of which one is designed for trickle charging and the other is a compound wound motor generator set and has capacity large enough to handle the entire control bus load. This set is only used during an emergency.

One of the newer automatic stations has an installation of rectifiers for trickle charging the battery and supplying the control lamp power. This type of charging equipment is limited to a small station where control lamp load is low, generally not over 3 amp.

The control equipment in small suburban and country stations is generally designed to trip the circuits. The equipment consists of a 24-volt storage battery with one of several types of rectifier. Some of the older stations were supplied with 120-watt motor generator sets designed to trickle charge the battery.

In a few stations the oil circuit breakers having a type W motor operator are closed and tripped by the 24-volt battery.

Fig. 3 is typical of connections for the above described equipment.

Alternating Current Control Equipment—This type of control is only used on small automatic rural stations. It is generally 220-volt, 3-phase, a.c., for closing the oil circuit breakers and tripping is done by two methods, one manually by 220 volts, single phase, a.c., and the other by action of the overload relays and tripping reactors.

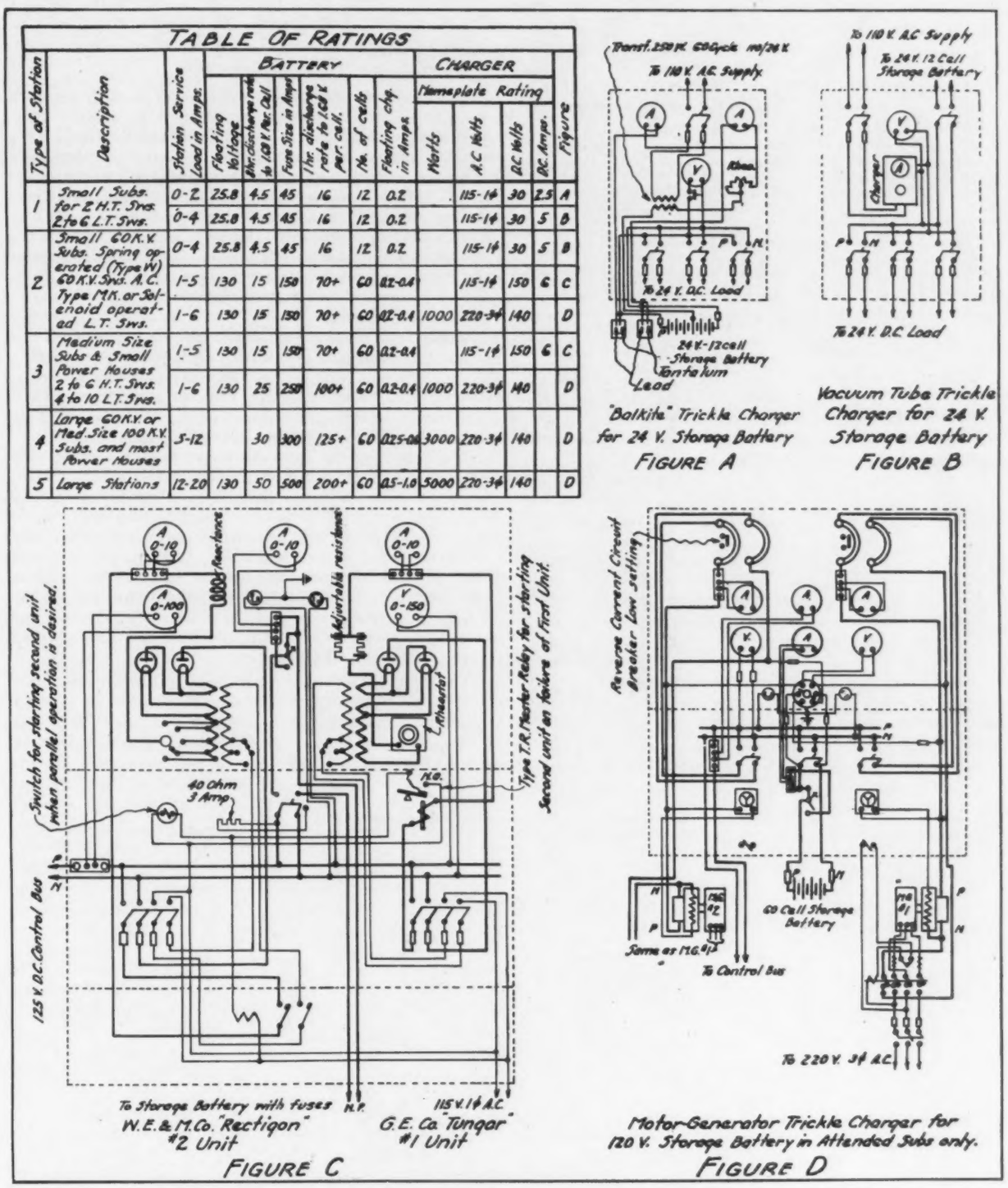
TABLE OF RATINGS
Type of Station
Description
Station Service Load in Amps.
Battery
Floating Voltage
Discharge rate to 1.81 V. Per Cell
Fuse Size in Amps.
1 hr. discharge rate to 1.81 V. per cell.
No. of cells
Floating chg. in Amps.
Charger
Nameplate Rating
Watts
A.C. Volts
D.C. Volts
D.C. Amps.
Figure
1 Small Subs. for 2 H.T. Srvs. 2 to 6 L.T. Srvs. 0-2 25.8 4.5 45 16 12 0.2 115-14 30 2.5 A
0-4 25.8 4.5 45 16 12 0.2 115-14 30 5 B
2 Small 60 K.V. Subs. Spring operated (Type W) 60 K.V. Srvs. A.C. Type MK. or Solenoid operated L.T. Srvs. 0-4 25.8 4.5 45 16 12 0.2 115-14 30 5 B
1-5 130 15 150 70+ 60 0.2-0.4 115-14 150 6 C
1-6 130 15 150 70+ 60 0.2-0.4 1000 220-34 140 D
3 Medium Size Subs & Small Power Houses 2 to 6 H.T. Srvs. 4 to 10 L.T. Srvs. 1-5 130 15 150 70+ 60 0.2-0.4 115-14 150 6 C
1-6 130 25 250 100+ 60 0.2-0.4 1000 220-34 140 D
4 Large 60 K.V. or Med. Size 100 K.V. Subs. and most Power Houses 5-12 30 300 125+ 60 0.25-0.5 3000 220-34 140 D
5 Large Stations 12-20 130 50 500 200+ 60 0.5-1.0 5000 220-34 140 D
Transf. 2500 V. 60 Cycle m/24 V.
To 110 V. A.C. Supply
To 24 V. D.C. Load
24 V.-12 cell Storage Battery
Tantalum Lead
"Balkite" Trickle Charger for 24 V. Storage Battery
FIGURE A
To 110 V. A.C. Supply
To 24 V. 12 Cell Storage Battery
To 24 V. D.C. Load
Vacuum Tube Trickle Charger for 24 V. Storage Battery
FIGURE B
Switch for starting second unit when parallel operation is desired.
Reactance
Adjustable resistance
Reactor
40 Ohm 3 Amp
Type T.R. Master Relay for starting Second unit on failure of First Unit.
125 V. D.C. Control Bus
To Storage Battery with fuses
W.E. & M. Co. "Rectigon" #2 Unit
115 V. 1¢ A.C.
G.E. Co. "Tungar" #1 Unit
FIGURE C
Reverse Current Circuit Breaker Low setting
60 Cell Storage Battery
Same as M.G. #1
To Control Bus
To 220 V. 3¢ A.C.
Motor-Generator Trickle Charger for 120 V. Storage Battery in Attended Subs only.
FIGURE D

Fig. 3. Ratings and connections for batteries and charging equipment for power houses and substations—Pacific Gas and Electric Company.

Generally two overload relays and one residual relay are used. The contacts of the residual relay energize the potential trip coil of the oil circuit breaker with 220 volts, a.c. Care must be taken that the station service transformer is connected to a phase that is protected by one of the overload relays.

Methods of Operation, Design of Control Systems and Operating Experiences

These topics are so closely interrelated that it has been thought best to treat them as a group with the following outline as the guide:

Methods of Operating:
- Particular emphasis placed on reliability.
- Advantages and disadvantages.

Design of Control Systems:
- Types for stations of varying capacities.
- Types of control wires and cables.
- Methods of installation.
- Protective features and devices for segregating trouble.

Operating Experiences:
- Common causes of trouble and remedies.

The response from the member companies has been very interesting and instructive from which the following is presented as covering the salient features.

San Diego Consolidated Gas & Electric Company—

Substations using d.c. control are: automatic reclosing without attendant, semi-automatic with attendant, non-automatic with attendant, and supervisory control.

All substations using alternating current control are automatic reclosing without attendant.

Direct current control layouts are used on all the important substations and receive their energy from storage batteries floating on the line and trickle charged by motor generator sets.

Alternating current control is installed in connection with gravity type reclosing mechanisms and used on the smaller substations in rural districts that require a better class of service but where economic conditions do not warrant building a major substation.

Where supervisory control is used, the control cable is a 5-pair, 19-gage solid copper, paper wrapped, lead covered cable. The cable is suspended in a messenger on the same pole line that carries 11-kv. and 4-kv. circuits. The messenger is not grounded. Fuse protection is provided on both ends of the cable.

A rigid monthly inspection has been maintained on the control equipment and with the possible exception of the supervisory, no particular troubles have developed. The supervisory control equipment is inspected weekly. When first installed, three years ago, a number of minor troubles developed but experience gained since the station has been put into operation, together with a thorough weekly inspection, have reduced these troubles to a minimum. The major sources of trouble are with the speed regulating devices on the distributor motor and the revolving brushes on the distributor arm.

Southern Sierras Power Company—

At important stations where a 125-volt battery serves as the source of d.c. control, an attempt is made to have this battery serve the one purpose of control only. This practice makes it necessary to use auxiliary sources of direct current for annunciator, telephone or telegraph systems. This practice is considered justified inasmuch as eliminating all auxiliary devices as mentioned above reduces the hazards which might affect the main source of d.c. control. Another standard practice is to keep d.c. and control circuits always in entirely separate conduits from a.c. power or metering circuits. As far as possible all control batteries are kept ungrounded.

In any installations dealing with new or special equipment a descriptive bulletin is always prepared for the benefit of the persons who will be in charge of operating the equipment. These bulletins contain photostats or photographs of equipment involved and a complete description covering its construction, installation and method of operation.

One bulletin of this type was issued dealing with the care, inspection and charging of storage batteries for stations using 125-volt lead type batteries. A nomographic chart was prepared for this bulletin which gives a ready means of determining the time specific gravity of a cell, having given the indicated specific gravity at any existing temperature. A straight edge placed on any point of the apparent specific gravity, when lined up with the proper temperature indication on the center scale, will cross the lefthand scale at a point which will indicate the time specific gravity as corrected for any temperature variation.

All control, metering and alarm circuits make use of 600-volt insulation, rubber covered conductor coded in colors as follows:

TABLE I—Code Wiring System

The Southern Sierras Power Company—Riverside, California.

Description of Circuit	Phase or Wire	Code Color	Size
Current transformer leads	A	Red	No. 8 to 100-ft., No. 6 over 100-ft.
	B	White	No. 8 to 100-ft., No. 6 over 100-ft.
	C	Blue	No. 8 to 100-ft., No. 6 over 100-ft.
	Neutral	Black	No. 8 to 100-ft., No. 6 over 100-ft.
Voltage transformer leads	A	Red	No. 10
	B	White	No. 10
	C	Blue	No. 10
	Neutral	Black	No. 10
Breaker Closing Wire		Red	No. 10
Breaker tripping wire		Blue	No. 10
Breaker green lamp or common lamps wire		Green	No. 10
Extra or red lamp or signal wire		Black	No. 10
Direct current feeder	Positive	White	As required
	Negative	Black	As required
Differential relay interlock trip		Green	No. 10
Temperature alarm circuit	Positive No. 1	White	No. 10
	Negative No. 2	Black	No. 10
Direct Current Supply bus	Positive	White	No. 2
	Negative	Black	No. 2
Voltmeter bus	No. 1	Red with white tracer	No. 10
	No. 2	Red with black tracer	No. 10
Synchroscope bus	No. 1	White with red tracer	No. 10
	No. 2	White with black tracer	No. 10
Frequency meter bus	No. 1	Blue with white tracer	No. 10
	No. 2	Blue with black tracer	No. 10
Alarm bus	No. 1	Green with white tracer	No. 10
	No. 2	Green with black tracer	No. 10
Ground bus		Bare copper	No. 2

In the absence of proper tracer code wire, the designated color of wire may be used and colored bands about ¼ in. wide painted around the wire at each end of the corresponding tracer color.

In the absence of proper code wire, any available color of the proper size may be used and the two ends painted with the proper code color for a length of at least 2 in. (Not for standard practice.)

This code applies particularly to *single* rubber covered conductors with colored cover braid, as now used on this system. Should use be made later of multi-conductor control cables, the same coding will be adhered to in a 7-conductor metering cable and a 4-conductor control cable.

As far as possible all control conduits in substation yards are installed in concrete trenches having removable wooden covers. This permits access to any conduit without the necessity of digging.

In substation buildings, the conduits are kept accessible as far as possible, only being imbedded in concrete walls or floors where absolutely necessary. Special effort is made to make these conduit installations as neat as possible.

At all major stations, control and metering conduits terminate in a cabinet above or below the switchboard containing terminals sufficient for all conductors contained in the conduits. The code wire terminates at this point and connection is made to switchboard wiring by means of these convenient terminals.

Terminal boards are always used at or near the base of switchboards to serve as a point of junction between control circuits and switchboard wiring.

Another important use of terminal boards is in connection with auto-balance current transformers used in balancing currents in transformer bank differential protection. The auto-balance transformers are mounted in a steel cabinet with a terminal strip directly beneath. All taps from these transformers are brought out to these terminals and the terminal board is stamped to indicate the proper lead. This practice improves accuracy, rapidity of making changes and neatness.

Although different control circuits may be required for equipment made by various manufacturers, an attempt is made to keep all circuits as nearly to one standard form as possible.

Interlocking, both mechanically and electrically, is used extensively in circuit breaker controls. Starting and running breaker electrical interlocks for synchronous condensers are standard practice. Electrical interlocking which prevents a motor operated air break transfer switch from being either opened or closed unless the oil circuit breaker of the corresponding circuit is closed is also used extensively.

Some difficulty has been experienced with water affecting rubber covered control leads and it is contemplated that in the future lead covered cable will be used.

Southern California Edison Company—

In installations of control wiring, including the secondary wiring for relays and meters, this company has at various times used:

(*a*) Colored rubber covered wires in iron conduit.
(*b*) Black rubber covered wires in concrete duct.
(*c*) Black rubber covered wire in fiber duct.
(*d*) Multi-conductor lead covered cables in fiber ducts.
(*e*) Is now using the multi-conductor lead covered cables with black rubber covered conductors.

Generally, the entire run or group of cables is massed in a single redwood duct, with iron conduit used for branch runs of one or two cables. Where the magnitude and importance of the job justifies, concrete tunnels are used with the cables separated, racked and marked. Construction within buildings consists of the conventional tunnels, trenches, and individual conduits. However, present practice calls for at least 90 per cent of the run outdoors.

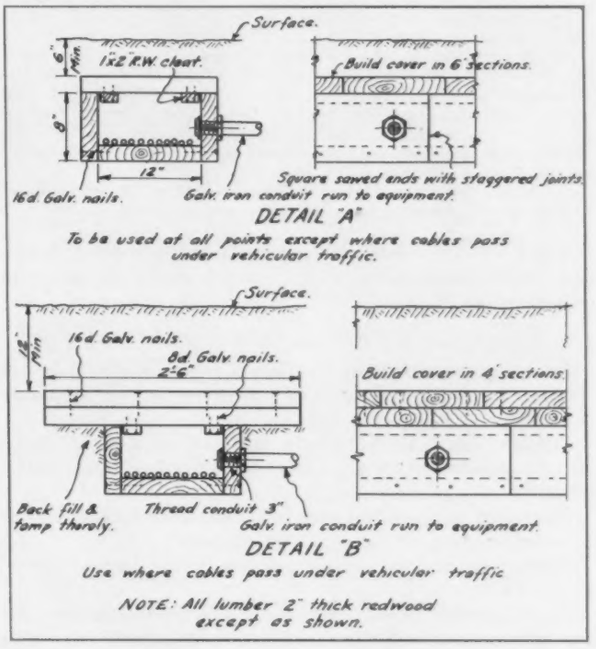
Surface.
6" Min.
1"x2" R.W. cleat.
Build cover in 6' sections.
8"
12"
Square sawed ends with staggered joints.
16d. Galv. nails.
Galv. iron conduit run to equipment.
DETAIL "A"
To be used at all points except where cables pass under vehicular traffic.
Surface.
16d. Galv. nails.
8d. Galv. nails.
2'-6"
Build cover in 4' sections.
Back fill & tamp thoroly.
Thread conduit 3"
Galv. iron conduit run to equipment.
DETAIL "B"
Use where cables pass under vehicular traffic
NOTE: All lumber 2" thick redwood except as shown.

Fig. 4. Details redwood ducts for control cables—Southern California Edison Company.

The Southern California Edison Company after trying supervised, unsupervised and partially supervised control systems, has adopted and has been using for several years, the last named system in which the burning of the red lamp indicates the existence of potential at each end of the relaying or tripping circuit but does not indicate the continuity of that circuit.

The standard multi-conductor control cable consists of four rubber covered conductors with black braid encased in a lead sheath. The four leads are used respectively for: closing, tripping, lights and alarm. Colored leads are not used but a brass sleeve marker is placed on each end of each conductor at the time of installation. Fiber discs are used to identify the cables.

Control and secondary cables are stranded conductors, with 600-volt rubber insulation and lead covered. The following are standard sizes and groups and are carried in stock:

"A" Cable—Current transformer secondaries, four No. 8.
"B" Cable—Potential transformer secondaries, three No. 12.
"C" Cable—Control, two No. 10 and two No. 12.
"D" Cable—Operating bus, solenoid breakers, two No. 0.
"E" Cable—Miscellaneous purposes, two No. 12.
"F" Cable—Station light and power, three No. 4.
"G" Cable—Station light and power, three No. 1.

NOTE: "A" or "C" cables with their leads paralleled are used as operating buses for motor operated breakers as well as electrically controlled air operated breakers.

Operating experience has emphasized the following points in control wiring:

(*a*) The control system should be divided into as many separate groups as is feasible in order to facilitate the location of grounds, etc.

(*b*) A sensitive d.c. ground detector should be used to detect incipient grounds.

(*c*) The closing and tripping circuits should start from the same polarity as the red lamp in order to provide the partial supervision previously mentioned.

(d) A pallet or auxiliary switch should perform only one function in order to avoid "sneak" circuits.

(*e*) Individual annunciation for remote controlled breakers using the slip contact control switch with bright-dim lamps and group annunciation for hand operated and automatic reclosing breakers.

(*f*) A permanent method of marking the leads at the time of installation seems to be preferable to premarking methods such as colors, etc.

(*g*) Segregation of control circuits beyond that which is supplied by the sheaths of the multi-conductor cables themselves is unnecessary.

(*h*) Grouped lead covered control cables in a common redwood duct seem to meet all requirements for outdoor runs including adverse soil conditions such as alkali except where it is necessary to cross public highways.

(*i*) Miniature control using telephone equipment offers many economies and seems to have the necessary reliability.

Fig. 4 shows the details of redwood duct for control, instrument and lighting cables. Fig. 5 shows wiring arrangement of control board.

Los Angeles Gas and Electric Corporation—

Reliability is considered of primary importance. To insure this, a systematic inspection of control equipment should be carried out.

Periodic inspection should be made of contacts on pallet switches, fuses, terminal blocks, control relays and control switches.

Insulation tests of the complete control system should be included as part of the construction tests.

Some method of indicating grounds on the control system should be included.

In generating stations and major substations, 30 per cent rubber insulated lead covered control cable is used. In other stations 30 per cent rubber covered wire is used.

TABLE II—Wire Data

Size of Conductor	Nearest Size A. W. G.	Thickness Insulation	Test Voltage	Insulation Resistance Meghoms per Mile
19 strands No. 25	12	3/64 in.	2500	1350
19 " No. 22	9	3/64 in.	3000	1000
37 " No. 22	6	4/64 in.	5000	850
37 " No. 20	4	4/64 in.	4500	750
37 " No. 18	2	4/64 in.	4000	650
61 " No. 18	0	5/64 in.	5500	600

TABLE III—Color of Braid on Individual Conductor

Number of Conductors,	
1	Black
2	" White
3	" " White and Red
4	" " " White and Black
5	" " " " Green
6	" " " " " Green and Red
7	" " " " " " Green and Black
8	" " " " " " " Red
9	" " " " " " " " Red and Black
10	" " " " " " " " " Red and Yellow

TABLE IV—Thickness of Lead Sheath for Lead Colored Cables

Outside Diameter Core	Thickness of Lead Sheath
Up to 0.625 in.	5/64 in.
0.625 in. to 1.25 in.	6/64 in.
1.25 in. to 1.75 in.	6/64 in.
1.75 in. to 2.0 in.	7/64 in.

All wires are stranded, insulated, and color coded in accordance with the following tabulation:

In indoor stations the control cables or wires are pulled in iron conduit. In outdoor stations fiber conduit laid in concrete between manholes with iron conduit between manholes and apparatus is used.

Circuit breakers with reverse current and overload features are used in motor generator set circuit.

Branch control circuits are protected by fuses rated not less than four times the closing current of largest breaker. Fuses in tripping circuits are rated at not less than six times the maximum normal current which they may be required to carry.

Main branch fuses have a standard switchboard indicating lamp connected across the circuit so that blown fuses will give an immediate indication.

Grounds on apparatus have been to a large extent our greatest source of trouble. These are due, for the most part, to the small clearances in pallet switches, terminal blocks, etc. The use of the highest grade equipment, together with careful inspection, has lessened this trouble.

The troubles which were formerly experienced with wire have been eliminated by the use of 30 per cent rubber covered wires and cables.

Faulty adjustment of pallet switches, control relays and control switches, have given some trouble—the answer being, rigid inspection.

In conclusion it is felt that, since the satisfactory operation of the system depends on the correct functioning of the control equipment, especially under abnormal system conditions, careful planning, best materials and rigid inspection should play a large part in the design, installation and operation of the control equipment.

Department of Water and Power, Los Angeles—

In order to obtain maximum reliability, all protective devices such as circuit breakers and fuses have been omitted between the battery and the main bus. Particular attention is paid to the quality of construction between these points. The control system of each station is divided into at least as many d.c. operating circuits as there are main bus sections. Each operating circuit is fed from the d.c. control bus through a fused switch with indicating lamp.

The disadvantage of this arrangement, of course, is the possibility of an unprotected short circuit between the d.c. control bus and the battery. This possibility may be made as remote as desired by tapping all exposed parts and similar precautionary measures in construction.

The advantage gained is the simplicity with which faults are located and localized in case of trouble. Each junction point in the d.c. operating circuit beyond its main switch is made through a separable link in order to facilitate testing. Furthermore, the same circuit controlling the field apparatus serves the corresponding section of the control board in the operating room. The advantages which accrue from this arrangement are obvious.

In all outdoor stations, lead covered, 30 per cent Hevea rubber insulated cable is used exclusively for all control and metering circuits. A d.c. operating circuit usually consists of two single-conductor lead covered cables. The oil circuit breaker control, protective relay and metering circuits are carried in 5, 7 or 9-conductor lead covered 30 per cent Hevea rubber insulated cables, the individual conductors of which are of uniform gage.

All indoor stations have their control and operating circuits run with 25 per cent Hevea rubber insulated wire in metal conduits and gutter boxes.

These cables and wires then are terminated in groups on terminal boards both at the field end and the control or instrument panel end. These groups of terminals are made through separable links similarly to those indicated above for the d.c. operating circuits, except smaller in size. They provide a convenient place for stenciling symbols which label the circuits, and the random appearance of the wiring at the junction of the switchboard and field circuits is thus avoided. Testing and alterations may also be readily accomplished without detracting from the neatness of the original switchboard wiring.

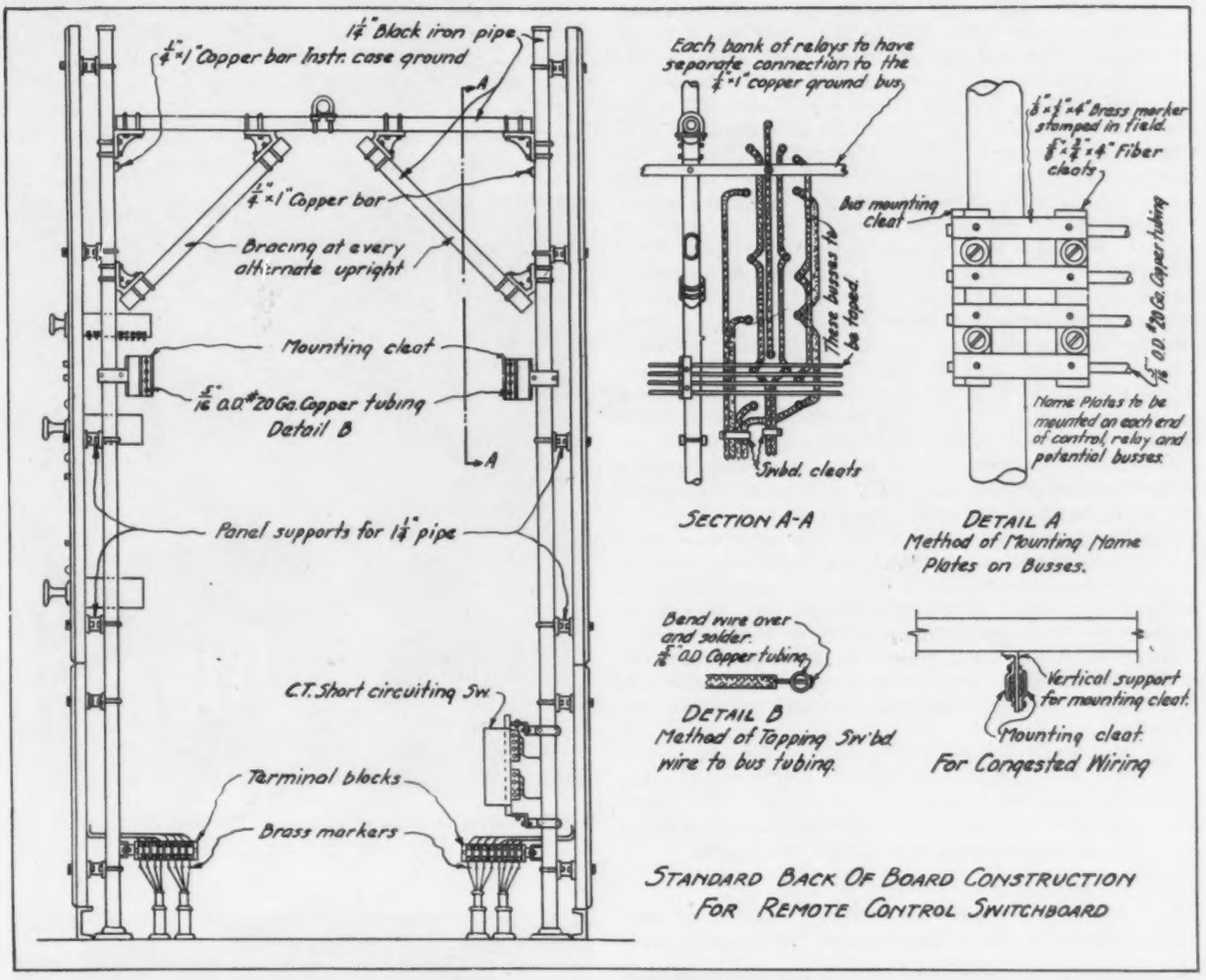
1¼" Black iron pipe
¼"×1" Copper bar Instr. case ground
A
¼"×1" Copper bar
Bracing at every alternate upright
Mounting cleat
⅝" O.D. #20 Ga. Copper tubing
Detail B
A
Panel supports for 1¼" pipe
C.T. Short circuiting Sw.
Terminal blocks
Brass markers
Each bank of relays to have separate connection to the ¼"×1" copper ground bus.
These busses to be taped.
Swbd. cleats
SECTION A-A
Bus mounting cleat
⅝"×¾"×4" Fiber cleats
⅝" O.D. #20 Ga. Copper tubing
Name Plates to be mounted on each end of control, relay and potential busses.
DETAIL A
Method of Mounting Name Plates on Busses.
Bend wire over and solder. ⅛" O.D. Copper tubing
DETAIL B
Method of Tapping Swbd. wire to bus tubing.
Vertical support for mounting cleat.
Mounting cleat.
For Congested Wiring
STANDARD BACK OF BOARD CONSTRUCTION
FOR REMOTE CONTROL SWITCHBOARD

Fig. 5. Wiring arrangement control board—Southern California Edison Company.

A ground indicating voltmeter on the operator's desk is connected between the center point of the battery and ground. This is a very sensitive device and gives the operator immediate indication of a ground fault anywhere on the control system. A ground may be quickly localized and cleared before more serious trouble can develop.

Operating experience clearly demonstrates that in the more important stations it pays to run control circuits in lead covered cable. By this use freedom from troubles and much greater reliability is secured. In the case of 250-volt control it has been found that long lead covered cables draw considerable charging current. However, this has not proved troublesome.

San Joaquin Light & Power Corporation—

This company has many of the older and less important stations where oil circuit breakers are manually operated so that relay and alarm circuits are the only control equipment. In the more recent stations all oil circuit breakers are remotely controlled. The control switch, relays and meters for each circuit are grouped vertically on the switchboard for simplicity in wiring. This applies to breakers whether they be transmission or distribution.

Control circuits in older stations are rubber covered wire in iron conduit. In present day designs, multi-conductor lead cable either armored or in iron conduit or fiber duct is used for all control circuits out of doors. Control cables are made up of No. 10 B&S gage solid copper conductors insulated with 30 per cent Para rubber for 600-volt service with distinctive color braids for identification. In the lead covered armored cable, two wrappings of steel tapes constitute the armor. Over this is first wrapped a serving of jute and then a layer of canvas tape wound half lap opposite hand to the jute. Both the jute and canvas are impregnated with asphalt compound. The finished cable is then dipped in asphalt compound to make it as corrosion resisting as possible. This cable is laid in the ground without boxing and from the standpoint of ease of installation and resultant economy, it is very satisfactory. However, none of this has been in service long enough (three years) to secure definite data as to its ability to resist corrosion. Five-conductor and eight-conductor cables are carried in stock and answer all ordinary requirements of control wiring leaving few idle wires in various possible combinations.

At Ashlan Ave. substation, where a large number of control circuits are required between the switchboard and the 11-kv. substation structure, an effort was made to secure most of the advantages of a control cable tunnel at a fraction of the cost of a full sized one. (See Fig. 8.) A concrete lined trench 2 ft. wide and varying in depth from 1 ft. 9 in. to 2 ft. 3 in., covered with checkered plate, was used. Lead covered control cables are laid up along the side of the trench on standard cable racks. The cables run from the trench to their destination in short runs of conduit. All con-

duits are graded to drain into the trench, the floor of which is pitched to a sump provided with a drain to carry away any water which might come through the cover which is not watertight. This arrangement gives ready access to the cables for inspection and facilitates additions or changes.

Control cables are brought into a pit running the full length of the switchboard. From here all control wiring is brought up to a terminal board near the bottom of the switchboard. Current transformer secondaries are all brought to test switches to facilitate the testing of relays and meters.

The d.c. bus for the operation of circuit breakers is divided so as to provide a bus for each section of the yard. This same bus energizes the control bus on the corresponding section of the board so in case of trouble on any bus causing the protective fuses to be blown, the control switch lights go out, thus indicating trouble. Each bus is fused separately and provision is made at the junction box in the station yard where the bus is branched and run over to the various breakers, to disconnect any branch readily if that section develops trouble. Fuses are of ample size to care for any combination of maximum control energy requirements with a safety factor of at least two. Each bus may be de-energized by a knife switch on the station board.

Troubles in control wiring are of few varieties. Short circuits in wiring in conduit due to the presence of moisture is the commonest difficulty in conduit installations out of doors. Lead covered cable has eliminated this. Damage to conduits and wiring by burning where ground wires cross conduit runs has occurred in several instances. As a result of this, special care is exercised to give considerable separation between ground wires and conduits to avoid this difficulty.

Batteries, motor-generator sets, and rectifiers in general have given very reliable service with few cases of minor trouble. This is particularly satisfactory as it has added materially to the reliability of the unattended station which occupies a large part in the operation of this system.

City and County of San Francisco—

It is believed that it would be desirable to recommend some standardization of control bus voltages. Apparently there are now five voltages in use for d.c. control systems, namely 12, 24, 40 and 125 and 250. As the lower voltages are not suitable for closing breakers, it is necessary to resort to manual or a.c. power for closure. All of this results in a multiplication of equipment types which is very undesirable.

There seems to be a real field for vacuum tube rectifiers for trickle charging control batteries at small stations. The

Fig. 7. Outdoor terminal arrangement, Moccasin Powerhouse, City and County of San Francisco

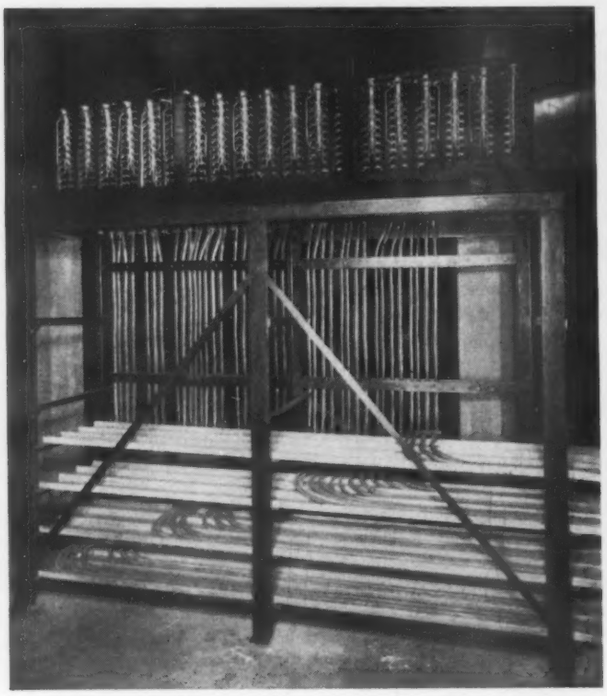

Fig. 6. Gutter box and control terminals—Station B, Department of Water & Power, Los Angeles.

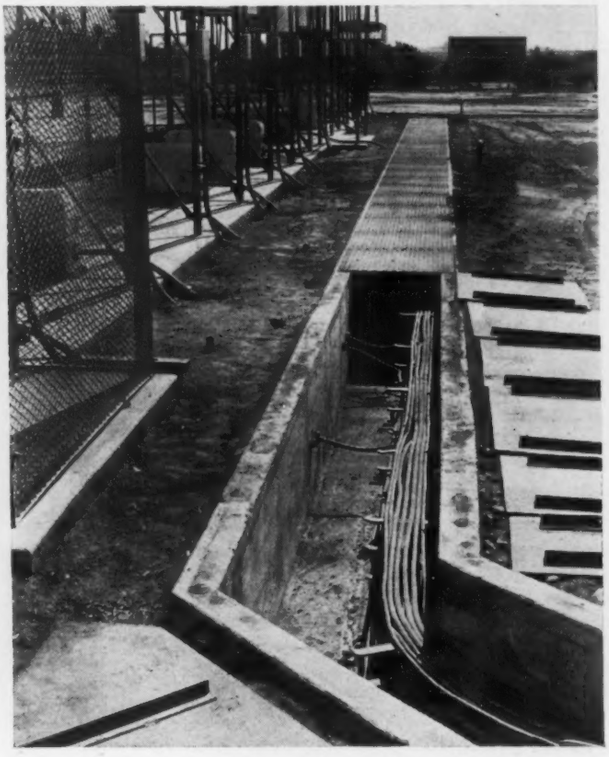

Fig. 8. Cable trench with steel cover—Ashlan Avenue Substation, San Joaquin Light & Power Corporation.

commercial types available are designed for radio or garage duty and are not entirely suitable for station work. Some use auto-transformers in place of insulating transformers, thereby communicating the ground on the a.c. supply circuit to the d.c. control system. Taps for adjusting the charging voltage should be designed so as to be used for floating the

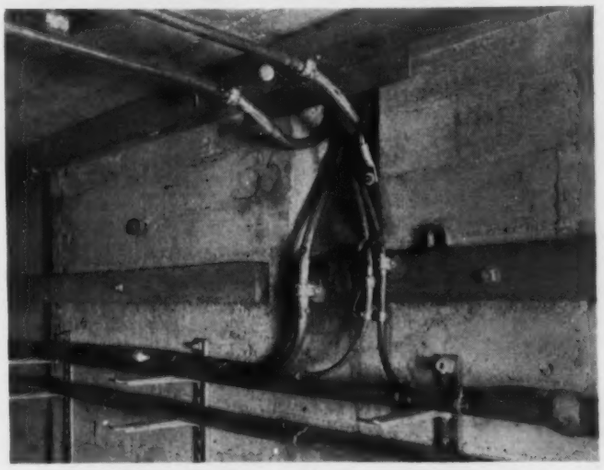

Fig. 9. Cables enter tunnel from breaker overhead—La Fresa Station, Southern California Edison Company.

battery. An accurate voltmeter should be included as standard equipment.

We are using a very satisfactory design of terminal board out of doors; shown in Fig. 7. The cover, not shown in the photograph, is fabricated as one unit and has a handle on top which enables it to be lifted off readily, thus providing a maximum of accessibility.

Remotely controlled, power-operated disconnecting switches should be interlocked to prevent opening or closing under load.

For control wiring we advocate best grade of insulation. On outdoor work we use lead covered cable in galvanized conduit. Where practicable, colored braids are employed for identification.

Pacific Gas and Electric Company—

Control systems are designed for reliability and dependability. The protection and segregation for control circuits are as follows:

Storage batteries are protected by very heavy fuses that can only blow in case of a short circuit in the loads to the switchboard. These fuses are generally located at the battery.

Each control circuit has separate fuses and a switch. The wires are pulled in separate conduits.

Each bus has its own control circuit and the control switches on the switchboard are wired to the same control circuit as the oil circuit breakers on the bus.

Relays on the main switchboard are connected to a separate control circuit.

Equipment such as generator, motor generators, converters, etc., where a number of oil and carbon circuit breakers, relays, and many interlocks are involved, have a separate control circuit.

All battery charging motor generator sets have two pole carbon circuit breakers with reverse current elements so that the generators will not motor.

Grounding lamps are installed. The size of lamps is kept small so that the current will not be large enough to trip circuit breakers due to sneak currents through the various interlock circuits.

The control circuits are made of a wire size large enough so that maximum voltage drop will not be more than 25 volts. The normal control bus voltage is 130 volts.

Operating troubles have been minimized by the precaution taken in separating and insulating the control circuits, so that grounds and faults on any one circuit can be easily detected.

Motor generator battery charging has given trouble in automatic stations due to voltage failing on the motor side and coming back; the generator would build up to a voltage less than the original value, the battery finally being run down. These motor generator sets are so small, the reverse element on even the smallest circuit breakers will not trip out.

Control circuits in conduits, using standard rubber insulated wire have given trouble due to the failure of the insulation. We now use wires having a very high grade rubber compound insulation.

New Developments

From time to time as the results of operating experiences passed on to the manufacturers of control equipment, come new and improved devices for control purposes. One of the manufacturers submits the following:

Control Switches—There are in use in various parts of the country three systems of control each requiring somewhat

Fig. 10. Cables are carried on racks in the tunnel—La Fresa Station, Southern California Edison Company.

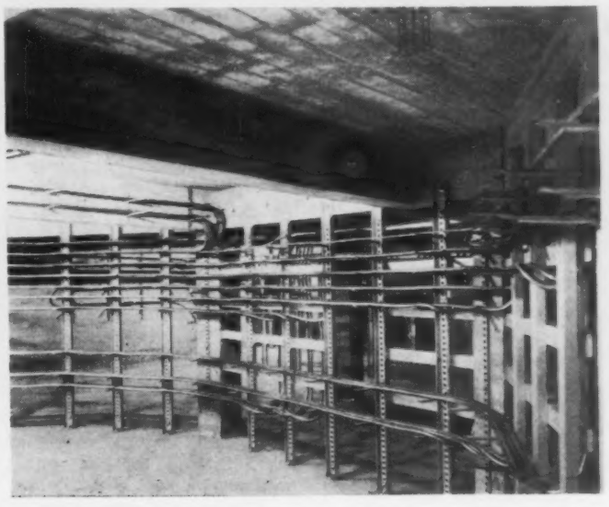

Fig. 11. Rack in basement under the switchboard—La Fresa Station, Southern California Edison Company.

different arrangements of control switches. These control systems may be classified as (*a*) single polarity, (*b*) double polarity (both having momentary contact switches) and (*c*) a system of control having "stay put" contact switches.

This company has developed control switches for all of the above systems, having pull button types, turn button types and turn pull switches.

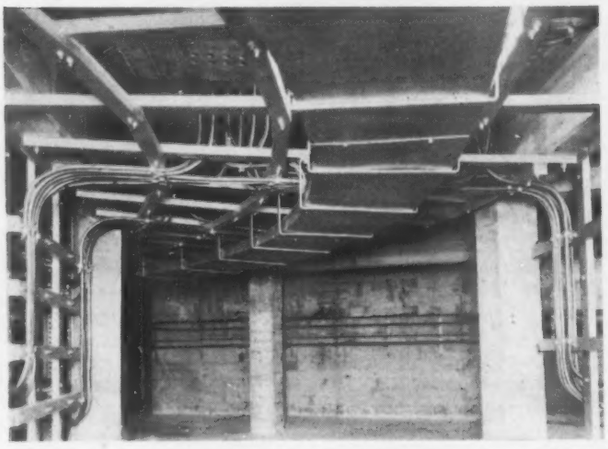

Fig. 12. Cable distribution under the switchboard—La Fresa Station, Southern California Edison Company.

The newer developments in control switches are mainly of the turn handle types, with protective covers over the contact mechanisms.

The circuit making or breaking contacts of these switches are of the silver to silver type since it has developed that this metal is most satisfactory for this class of service due to the fact that oxidation of the surface under long periods of inaction does not increase the contact resistance, and therefore a cleaning action is unnecessary for satisfactory operation.

Test Blocks—This company has also put on the market a line of safety type testing blocks and plugs to replace the former combinations of studs and links. These blocks have covers which are in place during normal operation, but are removed and replaced by a testing plug when tests are to be made.

The great advantage of these devices lies in the fact that the testing operator does not have to change any wiring connections, either on the board or on the testing equipment, between tests of a series of similar devices, the same plug being used successively in all test positions. A spare relay may even be connected to the test plug to replace automatically the switchboard relay during test.

Terminal Blocks—The present trend in switchboard construction is to furnish terminal blocks which have provision for markings to indicate clearly each control wire. Terminal boards from 4 to 38 poles are available in unit assemblies, and all boards are furnished complete with cup washers to act as terminal clamps for the control wires running to the blocks.

Fuses—This company recommends that all control circuits from the control board to the various pieces of apparatus be run as separate circuits and be protected individually by adequate fuses. The use of a separate control bus at the apparatus end of the circuits is not considered desirable practice.

Switchboard Wire—This company has recently developed an improved quality of switchboard wire for back of panel connections. This wire has a 750-volt insulation consisting of black varnish cambric tape next to the wire, which is tinned, then a felting of asbestos impregnated and finally a braid saturated with flame resisting grey paint. This new insulation has an extremely high dielectric strength (in the order of 20 times rated voltage) and is flame resisting to meet amply the prescribed test of the National Board of Fire Underwriters.

Miniature Control Systems—In line with an apparent trend towards concentration of control, there has been developed by this company a miniature control board which confines the instruments, control buttons and indicating lamps for one circuit to a strip 4 ft. wide in a control cabinet. This design of control board allows the installation of controls for fifteen circuits to be mounted in a cabinet on a 5-ft. table. The control system utilizes polarity relays for operation of remote devices.

Remote Control Devices—The control and operation of signal systems from operator's board to the engine or boiler rooms are important links in the proper conduct of generating plants. For this purpose, there has been perfected signal control panels or pedestals and indicating equipment utilizing Selsyn motors to get synchronized control and operation.

The Selsyn system can be adapted to a great variety of control schemes where signals or operations must be accurately duplicated at a remote point. Among the large number of applications might be listed operator's orders to engine rooms, water lever indication, governor position control, totalizing meter indication, gate valve position indication, etc.

Remote water level control of governor operation may also be obtained by use of Selsyn devices or may be secured through the use of the rheostatic balance method, such as is used in several generating plants on the Pacific Coast.

Summary and Recommendation

From these comments it is evident that reliability of control equipment is recognized as most important. This is being secured by many means, principally as follows:

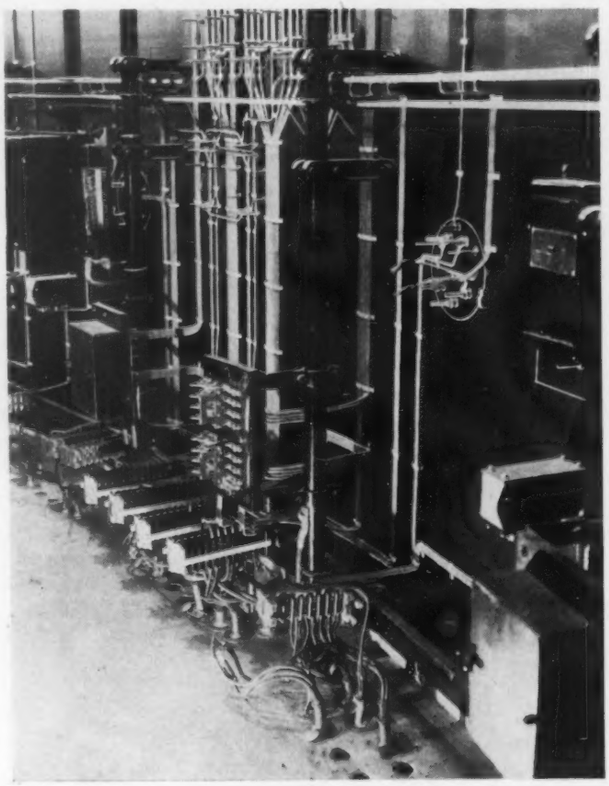

Fig. 13. Cable terminals at back of switchboard—La Fresa Station, Southern California Edison Company.

Greater thought and care in design and construction.
Use of the best materials available.
Rigid inspection at stated intervals.
Continuous indications of operating condition.
Segregation of fault conditions when such occur.
Elimination of lower control voltages.
Use of control batteries for control purposes only.
Give correct operating information to those responsible for control equipment.

Attention should also be given to the gradual elimination of non-standard control voltages. This can be accomplished by selecting proper voltages in new installations. The commonly accepted standards are:

Direct current—24, 48, 125 and 250 volts.
Alternating current—110, 220 and 440 volts.

The committee in presenting the foregoing summary urges that all of the features there outlined be given most careful attention for from such consideration results the most satisfactory operation and greatest reliability of whatever control equipment is installed.

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*Transformers and Regulators**

This report is made up of selected items taken from questionnaires and Engineering Section meetings. It covers the experiences of operating engineers in dealing with power transformers, induction regulators and reactors.

Some progress in overcoming oil leaks is reported. Acidity of transformer oil in service is shown to be organic and when accompanied by sludge, to be harmful. It also is a measure of rate of sludging.

Deposit from copper leads in unlined bushings has been stopped by use of copper screen or filled bushings.

Among the items suggested for greater ease in handling transformers in the field was the use of guides for removing cores.

Tap changing equipment is working very well, no cases of trouble being reported.

Some slight troubles in regulators and reactors are reported, but evidently this apparatus is giving good service.

THIS committee has endeavored to confine its activities to those subjects which were of special interest to the operating engineer.

In the furtherance of this policy, a canvass was made of the member companies as to what operating difficulties, in their opinion, could be helped through a study by this committee. From the many subjects brought forward, the following were selected as being of greatest interest:

Transformers—

Oil leaks
Acidity of oil
Leads in unlined bushings
Guides for cores
Tap changing equipment

Regulators—

Oil leaks
Broken tops and gears
Short circuit magnetic stresses

Reactors—

Operating experience with dry and oil immersed reactors
Field checks of losses and regulation

A questionnaire was used to gather information on these subjects and the following report is derived from the answers to these questions and from the discussion at the section meetings.

Section 1—Transformers

Oil Leaks—

Oil leaks, especially if the apparatus has been subjected to a long rail or rough road shipment, seem to be very prevalent and troublesome. Apparatus which has been overhauled in the shop and apparently freed of oil leaks, when moved and installed on the job may show numerous leaks. A number of methods of stopping these have been suggested, but most operating men think that there is still a great deal to be learned on this subject.

The majority of companies report leaks in new transformers as received. Complaint is also made of loose bolts, shifted cores, broken bushings, broken tap changers and poor gaskets in new transformers as received. These conditions are evidently due to strains in transit. There does not seem to be any decided preference for either rail or water shipment, as trouble is reported in the use of either route.

The manufacturing companies believe that they have made marked improvement in the location of leaks before shipment and also in loading for shipment.

Allis-Chalmers Manufacturing Company says:

Oil leaks in transformer tanks may be attributable to several factors which, taken individually or in combination, oftimes become a source of much aggravation and expense to the operating company and manufacturer. A review of the subject reveals that the major sources of oil leaks are caused by:

1. Stresses in the tanks during shipment due to improper or inadequate loading and bracing on the cars.
2. Design of the tank structure and supporting base which may result in weaving and/or distortion of the tank during lifting, or rolling operations when handling.
3. Poorly made gasket surfaces and assemblies for accommodation of tank-tops, bushings, hand-hole and manhole covers.

A careful study of item No. 1 revealed that swaying of the car or cars upon which the shipment was loaded, switching operations incident to making up trains, sudden application of power or brakes, introduced abnormal stresses in the shipment, particularly on long transcontinental hauls involving numerous transfer points, mountain grades, etc. A review of the conditions encountered during shipment resulted in a complete revision of loading and bracing specifications and a consequent practical elimination of leakages from this source. The improved method of loading and bracing, due to its simplicity, has also greatly reduced the time required in unloading a shipment after arrival at destination. The use of full length guide rails for definitely centering the core and coils in the tanks has materially assisted in minimizing tank stresses during shipment and handling as well as greatly facilitating the untanking and retanking of the core and coils.

The extent of weaving and/or distortion of the tank structure and supporting base as outlined in item No. 2 is largely dependent upon the design, weight and strength of the materials used, together with the methods of applying the lifting, jacking or rolling forces. It is desired that the design be such that application of these forces will result in uniform stress distribution in the tank structure. The type of transformer in which major lifting or rolling strains are taken through the base and external lifting rod structures is doubtless preferable to types in which these strains are taken through the tanks via lifting-ears or lugs attached directly to the tanks. Lifting strains in this last type of construction may cause weaving and/or distortion of the tank structure resulting in breaks in the welds of the tank itself, also in joints where tubes and radiators are attached to the tanks, unless the manufacturer uses extreme care to co-ordinate design with strength of materials. In the type of construction first mentioned the external lifting-rods and the tank bases are designed to care for handling-stresses, thereby minimizing tank stresses and the possibility of leakage incident to same.

Greater care on the part of the manufacturer in securing uniform gasket surfaces and assemblies for the accommodation of tank-

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* Report of subcommittee on transformers and regulators, electrical apparatus committee, Engineering Section. L. A. Buese, chairman. J. G. Corrin, H. H. Cox, Francis Curtis, D. J. Kelly, P. C. McCorkle, C. C. Potts, E. W. Rockwell, C. W. Smith, W. C. Smith.

tops, bushings, hand-hole and manhole covers, has greatly reduced the number of leakages from these sources. Closer and more careful attention to installation of bushings, etc., on the part of the operating company's installation crew will doubtless aid materially in reducing the leakages from such sources.

Several operating companies are specifying that the customary oil drain valves be eliminated from power transformers, thereby reducing oil seepage or leakage from this source. In such cases, the short nipple and flange customarily used in connection with the drain valve is provided with a flange plate into which a small nipple mounting a combination filter-press and sampling valve is welded. A short nipple from this small valve extends through the large nipple and downward into close proximity to the bottom of the tank for filtering and sampling the oil at the lowest practical point.

The General Electric Company has changed to a new method of testing for leaks which is described as follows:

Revolutionary changes have been made this past year in our factory in the testing of tanks for oil leaks. Testing with the use of water has been abolished and air under pressure is now employed by making a pocket around every weld and putting some 80 lb. pressure on this pocket. The air tests are then followed with hot oil tests. A very marked improvement indeed has been noted from this new procedure. Shipping strains apparently have a good deal to do with oil leaks, but it should be pointed out that one reason that leaks have shown up in the past after shipment is that it takes sometime for oil to filter through small openings in the welds.

The Westinghouse Electric and Manufacturing Company uses two different tests for leaks as follows:

During the process of manufacturing a transformer two different tests are made on the transformer tank, at two different stages in the manufacture, to determine whether the transformers are free from leaks.

The first one is a hydrostatic pressure test, using a pressure of five lb. per sq.in. The pressure is indicated by a gage located at the top of the respective tanks. During the test, an inspector goes over the entire tank, making a hammer test, using a two-lb. hammer. The operation is carried on by striking staggering blows adjacent to the weld seam. This work is carried on in the tank manufacturing department.

At a later stage, after the transformers have been completely assembled and electrically tested, another test for leaks is made in the final fitting department. The transformers, while filled with oil, are subjected to an oil pressure test of five lb. per sq.in., the pressure being measured at the transformer tank cover.

The pressure for both of the foregoing tests is obtained, in the first instance, by a static head of water and in the second by a static head of oil. The water level (or oil level) is adjusted to such a height in the reservoirs that the gage on the transformer cover will read five lb. per sq.in.

It will be noted that a pressure of five lb. per sq.in. is obtained on any welds around the transformer cover and at the top of the transformer. The pressure at the bottom of the tank will be greater than five lb. per sq.in. depending upon the height of the tank. On some of the higher tanks, the pressure may run up as high as 10 or 12 lb. per sq.in. on the bottom of the tank.

This method of testing will readily show up any leaks in the transformer tank and it is sufficiently high to show up any porosity of the welds.

These tests will tend to decrease the number of leaks in transformers as they leave the factory, but the operating companies think that more study should be given to the transportation end of this class of equipment.

After transformers are received, all of the operating companies give them an inspection. The routine as described by the Southern California Edison Company is a typical inspection. The procedure which transformers from the factory are subject to is as follows:

A thorough mechanical inspection is made for any foreign material, loose bolts, cracked supports, shifted windings and shifted laminations. The transformers are then made ready for the electrical tests, a copy of which is enclosed. Bushings are installed using new cork gaskets. Pipe fittings are removed and recemented in place, using a compound manufactured for this purpose.

When transformers are received with considerable moisture in the oil and windings, they are put in the vacuum tank and given a thorough drying out. The moisture is indicated by oil tests and megger readings. Transformers shipped without oil in a sealed tank under pressure seldom need to be dried out in the vacuum tank.

After filling the transformers with oil the real work begins in locating oil leaks and then trying to stop them. In looking around for a convenient way of locating oil tank leaks, it was discovered that blue chalk, when subjected to oil, turned dark. If this blue chalk could be applied easily a very fine oil leak detector could be had. One of the men, remembering how quickly bakelite thinner dried, tried a mixture of blue chalk and bakelite thinner. From then on this mixture has been used to determine oil leaks in the shop. All leaks in tanks are electric welded and those in bushings are stopped by properly fitting cork gaskets.

When riveted transformer tanks are received, the rivets are welded.

The following tests are now made on new station transformers:

1. Check gas pressure
2. Inspection
3. Fill with oil
4. Ratio on all connections
5. Polarity
6. Resistance
7. Impedance watts and volts
8. Warm up for hot megger and oil test
9. High potential ground
10. Core loss watts and exciting current
11. Check for oil leaks
12. Cold megger and oil test
13. Check on temperature indicators
14. Heat runs on special or new designs

The following tests are made on new regulators:

1. Inspection
2. Fill with oil
3. Ratio
4. Phase relation
5. Phase rotation
6. Tag leads
7. Megger and oil test
8. High potential
9. Core loss watts and exciting current
10. Ratio and polarity of current and potential transformers
11. Check auxiliary control circuits
12. Heat runs on special and new designs

After transformers are shipped to the job, additional oil leaks often develop and these leaks are hard to stop, most companies reporting failure. The Pacific Gas and Electric Company says it endeavors to stop the leaks which show up on the job, but without very much success as far as tanks are concerned. Gaskets are replaced, using an oil proof varnish. A cheap grade of cork is very porous and should not be used for gaskets. Pipe nipples are removed and the threads are painted with oil-proof varnish which has been mixed with Princess Metalic.

The Southern Sierras Power Company, the San Diego Consolidated Gas & Electric Company, the San Joaquin Light & Power Corporation and the Los Angeles Gas and Electric Corporation all report similar troubles and usually find it necessary to remove the oil and replace gaskets before transformers are finally put in service. Threaded pipe fittings are generally removed and replaced, using either one of the mixtures designed for this purpose or else a mixture of litharge and glycerine. The latter mixture is seldom used on joints which may require frequent removal as it seals so tightly that it is difficult to break the joint again.

Acidity of Transformer Oil—

Trasformer oil is usually bought under a contract specifying a neutral or low acid test and yet when transformers have been in service a short time, this acidity increases gradually over a long period. The questions naturally arise, "What of it?" and "What is the danger, if any?" and "What causes this acidity?" and "Has it any relation to insulation breakdowns?"

Transformer oil has been the subject of observation and experimental study ever since transformers were first im-

mersed in oil, and even now after this long experience, it is sometimes difficult to put one's finger on any particular characteristic and say definitely what is its limiting safe value. One oil test which is certainly absolutely definite, especially when it is definitely negative, is the breakdown test. The test tells whether the oil will insulate or not when in its tested condition.

Other characteristics can be stated as relatively good or bad, but the value of the goodness or badness is often a matter of opinion. Moreover, such values must be considered in conjunction with the values of other characteristics. Acidity is one of these characteristics.

Only the larger operating companies buy oil under a rigid specification. The smaller companies usually buy oil on the market and testing of oil is incomplete. These companies testing new oil use the A.S.T.M. method or a modification to suit the degree of completeness desired. The practice of those companies doing testing is outlined by the Pacific Gas and Electric Company as follows:

Not more than 0.05 mg. of potassium hydroxide shall be required to neutralize one gram of oil, A.S.T.M. method D-188-24 T. We make tests from tank car samples as follows: Specific gravity, flash, pour point, viscosity (Saybolt universal) at 100 deg. F., neutralization number, heat, life test, corrosion, dielectric strength, unsaturation test and resistance to emulsion number.

Tests show that this oil when placed in service shows an increase in acidity. These tests are described by the Pacific Gas and Electric Company:

METHOD OF TEST

The oil was tested according to the A.S.T.M. method for the neutralization number of petroleum products. Both the general neutralization number and the mineral acid neutralization were determined as expressed in milligrams of potassium hydroxide per gram of oil.

Tests to determine the presence of sulphuric or hydrochloric acids were also made.

RESULTS OF TESTS

The results are to be found in the following table:

TABLE I—Result of Test

Age	Sample No.	Color	Neutralization Numbers General	Mineral Acid
6 Years	A	Light Brown	0.37	0.00
8 Years	B	Brown	0.24	0.00
8 Years	C	Brown	0.36	0.00
4 Years	D	Reddish Brown	0.52	0.00
2 Years	E	Yellow	0.13	0.00
2 Years	F	Yellow	0.05	0.00
2 Years	G	Yellow	0.02	0.00
1 Year	H	Yellow	0.02	0.00
2 Years	I	Yellow	0.05	0.00
20 Years	J	Red Brown, Sediment	1.10	Trace
4 Years	K	Light Brown	0.17	0.00
9 Years	L	Light Brown	0.19	0.00
24 Years	M	Red Brown, Sediment	1.08	0.00
3 Years	N	Brown	0.18	0.00

The general neutralization number represents the total acid content, both organic and mineral. Since the mineral acid content is zero, it is evident that these oils contain organic evidence of sulphuric or hydrochloric acid. In the one exception there was a trace of hydrochloric acid probably formed from action of the acid in the oil on the soldering flux.

CONCLUSIONS

All these oils contain organic acids in varying amounts. The mineral acid content is zero. The organic acids are oxidation products formed by the heating and ageing of the oils.

The Southern California Edison Company says:

Occasionally tests for acidity of insulating oil are made while it is in service. These tests are usually made when the sludging is pronounced and more for the reason of knowing more about the acid condition than as a criterion as to whether oil should be replaced. After a few years of service the acidity rises to a point where it takes about 1.0 mg. of KOH per gram of oil to neutralize. This does not seem to be harmful and just how much greater an acid condition is permissible we do not know. When the acidity of the oil has reached the point where it requires 1.5 mg. of KOH per gram of oil to neutralize, there are usually other conditions, such as excessive high carbon and moisture content, which indicate that the oil should be changed.

From the tests that have been made there is every indication to believe that acidity, like sludging, is one of the end products of oxidation. The sludge in the oil may be quite acid while the oil itself is only mildly so. After filtering, the acid condition of the oil changes but little and the oil will pass the test for dielectric strength. So far there does not seem to be any relation between acidity and dielectric strength, except in so far as those agents which increase the acidity of oil also reduce the dielectric strength. The acids in the oil are the organic type and will not attack metal. It is questionable whether the acids attack the insulation fabric. Tests to determine this feature are now in process but have not gone far enough to reach any conclusion. It seems as though the varnish covering of the insulation would protect the insulation from the acid. Tests are now being conducted to determine this feature.

The following comments are taken from discussion at section meetings and represent to a large extent the opinion of the manufacturers on this subject:

Allis-Chalmers Manufacturing Company—

Acidity alone with no oxygen or water present may do little harm as long as its value is not extremely high. Yet moderately high acidity in conjunction with water may cause great trouble. Acidity with moisture lowers the dielectric strength faster than acidity alone.

Attacking by the acid of parts above the oil, such as tank covers, bushing cement, etc., has been evident in many cases. This is almost always the result of the combination of acidity, moisture, oxygen and heat. The attacking of insulation or other materials in the transformer proper under the oil has not been experienced even with what might be considered very high acidity.

If adequate arrangements are made to keep the oil dry and to keep oxygen away from its surface, it is known that not only is acidity less dangerous, but also that it is less likely to be increased in service to a high value. The test for acidity in new or reconditioned oil should show a neutralization value of less than 0.08 mg. of KOH per gram of oil. The question has been raised as to how high the neutralization value should be allowed to rise before it is necessary to recondition the oil. The answer can only be indefinite. If the oil is dry, of a good color, and shows little sludging, it might safely have an acidity represented by a neutralization value of 1. On the other hand, oil with much lower acidity has given trouble and has had to be replaced. This can only be summed up by saying that if transformer oil is originally good, has high dielectric strength, is kept free from moisture and has not sludged, the actual acidity becomes somewhat a secondary consideration.

General Electric Company—

It is important that new oil for transformers and regulators be entirely neutral, as any traces of sulphuric acid which is used in the refining of the oil, would tend to harm the soldered joints, etc., and also deteriorate the insulation. Acids formed during the oxidation of oil are very weak acids and appearently have little or no effect in the ageing of insulation. The two factors, however, value of acidity and color of oil—do give a definite indication of the rate of sludging. The matter of sludging is particularly important because of the possibility of blanketing the dissipation of heat from the coils after the oil finally becomes saturated with oxidized product.

Westinghouse Electric & Manufacturing Company—

If water is poured into or agitated with new transformer oil, the water droplets will quickly settle to the bottom of the vessel and the dielectric strength of the oil is not greatly lowered. On the other hand, if old oil is used for the above test, a much longer time is usually necessary for the separation of the water. Owing to the slow separation of the moisture, the dielectric strength is poor over a long period of time. The R.E. (resistance to emulsion) or the S.E. (steam emulsion) number is the generally accepted method of expressing this characteristic of the transformer oil. The importance and meaning of the R.E. number will be discussed in the following paragraphs.

The method for determination of the R.E. number of oil is explained in detail on pp. 10 and 11 of report I.B. 5336-A. In general, the procedure is as follows: A previously measured volume (20 c.c.) of the oil sample is maintained at a given temperature by passing slightly superheated steam through it. When sufficient condensation of steam has taken place to give approximately 20 c.c. of water emulsified with the oil, the steam is cut off and the emulsion quickly placed in a separating bath operating at a definite temperature. The time in seconds necessary for 20 c.c. of the oil to separate from the emulsion is considered the S.E. number of the

oil. The time required for separation of 20 c.c. of new Wemco "C" oil under the specified conditions is usually found to be from 10 to 20 seconds. This time in seconds will, therefore, be the R.E. number. Serviced oils give variable results, the R.E. number depending upon the conditions under which the oil was used. Samples of serviced oils have sometimes given values as high as 1,200 seconds, which, of course, would indicate that admission of water into the apparatus containing such oil would be dangerous.

There are a number of factors which influence the R.E. number of oils, chief of which is the presence of certain impurities. The presence of impurities in serviced oil is accounted for by oxidation of the oil, solution of small amounts of insulating varnishes and formation of small amounts of metallic soap. Quantities of impurities which cannot be determined by the usual analytical methods can readily be detected by the steam emulsion test.

At the present time, it is not possible to specify a maximum value for the R.E. number above which it is dangerous to operate the transformer. If it were possible to set limits, different limits would be necessary for particular types of transformers. In general the importance of keeping the oil in the apparatus free from water increases with the increase in the R.E. number of the oil.

The R.E. number of the oil in Inertaire transformers is of little importance since the entrance of moisture into the tank is prevented. A dehydrating breather is desirable with expansion tank and air cushioned transformers, especially when the R.E. number of the oil is high.

A summation of the above study of acidity of transformer oil in service is here given:

1. It is organic acid and not mineral acid.
2. It is formed by the heating and ageing of the oil.
3. Acidity below neutralization number 1.0 is not harmful if oil is otherwise up to test.
4. When accompanied by sludging or carbon, it is dangerous.
5. Acidity, together with color of oil, give an indication of rate of sludging.

Copper Leads in Unlined Bushings

Most of the operating companies report some previous trouble with corrosion and deposit from copper in unlined bushings. Various methods have been used to overcome this trouble, the most common method being the installation of wire screen around leads, bonding same to lead at top and bottom. The Pacific Gas and Electric Company also says:

We have installed breathers in the tops of transformers to allow a free air circulation, especially in the dead air pockets such as bushing turrets. Our method is one breather for each foot in diameter, located symmetrically around the cover as low to the oil line as possible, one in the manhole cover, and one in each bushing turret. The breathers are made of one 1-in. pipe sleeve, one 1-in. nipple, one 1-in. street ell and one 1½-in. to 1-in. bell reducer. The reducer has a disk of perforated sheet copper inserted in the bell held in place by a brass ring nut. The sleeve is welded in the cover in a horizontal position.

It is our opinion that this will eliminate the collection of moisture on the under side of cover and on the bushings. However, we have not had a chance as yet to prove this theory entirely as it will take a year or so to make a comparision.

We have made one trial of ground cork mixed with oil-resisting varnish and spread on the under side of cover, to eliminate the collection of moisture which we think is the source of trouble.

We have dug the soft litharge away from the shells of the bushing and flanges, using Portland cement (mixed with one-third sand and enough water to hold the cement together) to fill up the space. After setting, the surface is given a coat of oil-resisting varnish. The cement must be tamped in place with a stick. The oil fumes do not seem to attack the cement.

In bushings of the hollow porcelain tube variety we are now using a solid copper conductor through the bushing, from a cap on top, and expanding a thin walled lead tube tightly against the inner porcelain wall This tube is spun over at the ends and connected solidly to the cap so that it is at the same potential as the conductor, thereby eliminating static discharge within the tube and preventing corrosion and radio interference.

The Southern Sierras Power Company states that:

In a few cases we have had trouble from leads being corroded to such an extent that service was impaired. This occurred on potentials of 33 kv. and above. Invariably we have found most of our cases in making inspection and repair. To remedy this we have installed copper tubing lining and to date we have not experienced any trouble—however, neither have we had opportunity to inspect bushings so repaired. They have been in service for over a year without trouble.

The remedies so applied have as yet not been in service long enough to give a definite answer as to their effectiveness, but another year of operation should bring out definite results.

Guides for Transformer Cores—

In the majority of smaller substations, facilities are not available for handling transformer oil except by barrels or temporary tanks. This makes the untanking of a transformer core a messy and tedious job. Most transformers are so designed that the oil must be removed to insure reseating of the core. To overcome this difficulty, the Southern California Edison Company suggested guides inside the case, so that the transformer core could be untanked and retanked without removing the oil. It was also suggested that these guides would act as braces during shipment and prevent some of the trouble due to cores shifting during shipment.

The idea appealed to the operating engineers and received much favorable comment, and at least two companies besides the Southern California Edison Company are now purchasing transformers equipped with these guides. It is hoped to have some information regarding their use next year.

The manufacturing companies said the scheme offered no difficulties.

Tap Changing Equipment—

Tap changing under load has now been in service for several years and operating experiences are now available. It is gratifying to note that these experiences have been very favorable to the use of this equipment.

The reports of the operating companies speak for themselves:

San Joaquin Light & Power Corporation—

The San Joaquin Light & Power Corporation has been using equipment for tap changing under load for several years with very good success in general. The first installations were added to banks that had been in operation and were manually operated by means of proper switches with a regulating transformer and reactors while the operations were made. This type has been very satisfactory and no trouble has been experienced with them.

The first installation of an automatic tap changer was made with transformers having a forked winding, which had the same impedance but with voltage taps brought out staggered, as you might say, on the ground ends. When the voltage was normal one winding carried the load, the other winding being open on the tap end. These windings were not connected on the tap ends except when a tap change was being made and then through air type contactors with no reactor in the circuit. The circulating current produced by the difference in voltage between the two windings was to be held down by the characteristics of the two windings.

Under actual operating conditions this circulating current was found to be greater than calculated and trouble was experienced with disconnects on this installation. Also the ebony asbestos board on which the contactors and disconnects were mounted caused trouble after a flashover due to an error in switching on one transformer. The ebony board was scraped and shellaced, but immediately flashed over on being put into service. It was found that the leaks to ground were about ¼ in. under the surface of the board and this breakdown occurred at the time of the flashover. The maximum voltage to ground at any time on this installation is about 800 volts. According to manufacturers' data, ebony board should hold up to about 500 deg., so it would appear that it should be thoroughly inspected when subjected to arcs.

This company has a number of installations of automatic tap changing in which taps are changed by air and oil switches in which a reactor is used to limit the circulating current from one tap to another and they have been very satisfactory. The trouble experienced has been in the mechanical construction of the tap-changing equipment, such as too critical construction of cams, etc. Most of our installations use air break contactor switches and these have operated satisfactorily to date.

All tap-changing installations are so laid out that by means of disconnecting switches they can be cut out of service for inspection. This also applies to induction regulators as well and has been very opportune at times. Also we have a time delay relay in between the contact-making voltmeter and the control motor using approximately a minute delay before a change can be made. This was felt to be necessary, as it would prevent the apparatus working

continuously, and gives very satisfactory regulation as well. It will also prevent operations at times of short circuits on feeders and during system disturbances of short duration. All installations are step by step, that is, by about 2.5 per cent steps. After one change is made, there is a period of delay, due to the timing relay, before another change is made. On one installation we found that it was possible to get three changes at one time, due to the circuit making on the timing relay for a period of time longer than desired. This may be advantageous in the event of low or high voltage conditions on the system which continue for quite a period of time. These extra changes will not take place, however, if they are not required to bring the voltage to normal. On this same installation we have experienced some trouble with the contacts on the oil circuit breakers burning on account of being closed slowly by cams. On another installation we had the operating motor stick, due to rust getting under the brake. This indicated that the manufacturer should make the housings weatherproof and of more stable construction.

Pacific Gas and Electric Company—

The Pacific Gas and Electric Company has found its equipment for changing taps under load very satisfactory, on the whole. We have a comparatively large number of installations, both manually and automatically operated and all are used for secondary bus regulation. We have no tap-changing equipment used for adjustment of transmission voltages.

Our equipment is all made according to our own design, either in our own shops or those of a local manufacturer We have naturally experienced a few troubles from time to time, but weaknesses have been corrected as they have shown up, and considering the number of equipments in use and the length of time they have been in service, our troubles have been remarkably few. Since these mechanical difficulties are peculiar to our own make of equipment, they can be of little general interest and will not be detailed here.

We have experienced no difficulties in application of this equipment. It has been described in detail in past reports of this committee.

Southern California Edison Company—

The tap-changing under load transformers have so far proved very satisfactory, in fact, so satisfactory that very little information is obtainable. At present there are four installations, as follows:

Uplands Substation 1—General Electric 9,000 kva., three phase, 11 kv.

Harbor Substation 4—Westinghouse 20,000 kva., single phase, 72/110 kv.

Saugus Substation 4—General Electric 25,000 kva., single phase, 72/220 kv.

Los Angeles No. 3 Substation 3—General Electric 30,000 kva., three phase, 30 kv.

The tap-changing transformer at Uplands is a three-phase transformer placed in the neutral of the 11-kv. side of three 3,000-kva., 66/11-kv. natural cooled General Electric transformers. An exciting winding energizes a series winding (connected to the neutral side of the power tank) raising or lowering the 11-kv. voltage. Motor operated oil circuit breakers connect the series winding to ground. A reactor in the tap-changing transformer is used to absorb the energy from the short-circuited windings at the time of changing taps. Seven voltage position are obtained, three above and three below 11,500 volts, each tap being 2 per cent of 11,500 volts.

This tap-changing transformer has had the opportunity of carrying 110 per cent load. At this point the circuit breakers became quite warm, while the rest of the transformer remained cool. The box in which the circuit breakers are mounted on the side of the transformer was provided with better ventilation and with this change the overload was easily carried. It does not seem proper that an accessory, such as oil circuit breakers should limit the capacity of a transformer bank.

At Harbor substation there are four Westinghouse transformers (one spare) 20,000 kva., single phase, transforming power from 66 kv. to 132 kv. The tap-changing winding is on the 132-kv. side, which is grounded. Oil circuit breakers connect to each tap, shorting the turns through a reactor very much in the same manner as the General Electric transformers at Uplands. Nine voltage taps are obtained, each being 2 per cent of 132,000 volts.

This tap-changing equipment occupies considerable space adjacent to the transformer but has given perfect operation.

At Saugus substation there are four General Electric 25,000-kva., single-phase, 220-kv./72-kv. tap changing transformers. The tap-changing side is 72 kv. delta connected. Nine voltage positions are obtained, each varying in steps of 1.5 per cent of 72,000 volts. The tap-changer is motor operated and the mechanism is often referred to as the "crab type" because of the peculiar motion it makes. The tap-changer is connected to the middle of the 72-kv. winding and is connected to a reactor which absorbs the energy of the shorted turns.

Perfect operation of this transformer has been obtained.

At Los Angeles No. 3 substation there are three General Electric 30,000-kva., three-phase transformers each connected in series with a bank of three 10,000-kva. transformers, 66 kv./33 kv. This tap-changing transformer is essentially three single-phase regulators in one tank. There is a series winding in the 33-kv. line which has its voltage raised or lowered to obtain nine different voltages each, in steps of 1.25 per cent of 34,600 volts. There is an "exciting winding" connected in star to the 33-kv. line. This winding induces a voltage in the "regulating winding" where the voltage is varied. The mechanism for varying the voltage is the so-called "crab-style," the same as used on the General Electric transformers at Saugus. Power from the "regulating winding" is then used to excite the "excited winding" which is on the same core as the series winding.

This installation is quite recent but has given perfect satisfaction. From the above it is seen that, although only two methods of tap changing have been used, the oil circuit breaker type and the so-called "crab type," the applications are somewhat different. So far all have proved satisfactory and little or no preference is given to either type.

New Designs—

Suggestions for transformer improvements, brought out the following requests:

Men handling transformers have complained about the lifting lugs on one make of transformer. One company uses steel hooks for raising transformers, which slip out unless held in place until under strain; it is therefore necessary to use two men, one to hold hooks and the other to operate crane. Several shipments of transformers have been received with cases rusted on the inside, making it necessary to pull the core and scrape them. This company finds that the covers do not fit tightly on transformer cases made from pressed steel, which allows rain to enter during storms. It finds, too, that pressed steel cases become rounded on the bottom, due to the core resting on them. After being retired from the job, the core must be pulled and the bottom straightened before being sent out on another job.

All new power transformers are now specified with guides for the cores. Jack pockets are sometimes located so that it is very difficult to get the jack in position due to projecting cooling coils. Then again the jack pockets will be too small. However, certain types of hydraulic jacks have been found to fit such conditions.

The oil line between the conservator and transformer tank has often been so small that in filling the transformers from the bottom with large filter presses, the oil will leak through the bushings rather than go up the pipe to the conservator. A 2-in. pipe is now being considered. It will be interesting to know to what degree this will defeat the object of the conservator tank.

On some transformers it is quite difficult to reach through the manhole to the terminal board to change the voltage taps. A larger manhole or more accessible location of the terminal board to the manhole would be desirable.

Tap changers have caused some trouble through springs on the sliding type contacts, and contacts with rollers on the roller type.

A good ratio adjuster is a very inexpensive item and will save its weight in gold many times over in the life of a transformer.

There is nothing more disagreeable and expensive for the amount of work necessary to change taps on a bank of transformers, than to have to draw down the oil and reach in simply to loosen two nuts and move one bar.

It is interesting to note that the ratio adjuster still comes in for a great deal of criticism, despite the attention that has been given to it each year.

Section 2—Regulators

The cases of operating troubles with induction regulators were isolated and in general seem to be bearing troubles.

San Joaquin Light & Power Corporation—

One segment on an induction regulator changed due to teeth being cut away by worm gear on operating motor. Replaced with

new segment. Apparently original segment defective as new one had to be relined to operate properly. Several cases of rotors sticking due to bearings. No trouble found on inspection. Apparently something in bearing which came out when rotor was removed.

Pacific Gas and Electric Company—

One of our greatest troubles is the bearings, especially with regulators having bronze bearings. However, they are in service from three to five years before we do much work on them.

The reason for most of this appears to be due to a poor fit to begin with and the continual hammering wears them on two sides. In our shops we make a fit as close as they can be worked on by hand. We have two or three cases where, under short circuit, the motor frame was broken due to the torque caused by short circuit. These parts have been made stronger by the factory. In one case where the worm and gear was not properly greased, the teeth wore out. New grease systems have been installed on late regulators by the factory.

The Southern Sierras Power Company—

We have had one experience of electrical failure in a new 36-kva. single-phase, 2,400-volt induction regulator operating on 4-kv., 4-wire, 3-phase system that raised several questions. Failure started between turns on the stator, burnt through the slot and flashed to the rotor. The no-voltage relay motored the regulator to the full buck position. This subjected the rotor to quite a burn, which raised the question of preventing the regulator from motoring in case of internal failure. In addition, the oil pressure rose so high within the regulator that the outdoor top hood was literally blown off and glass from the windows was found 100 ft. away. It is felt that for safety reasons the manufacturer might well provide a relief valve for high internal pressures.

Los Angeles Gas and Electric Corporation—

Three failures of windings; one regulator top and the bulging of one tank under short circuit stresses. Noise due to worn bearings has been very noticeable.

Section 3—Reactors

The continued use of reactors by those companies using them is shown by their reports.

Southern California Edison Company—

Reactors are desirable in distribution circuits for limiting the short circuit stresses. This permits smaller circuit breakers and lighter duty bus construction. Circuit breakers may be installed at a station equipped with reactors and remain there regardless of the extent to which the transformer capacity is enlarged. With reactors placed on each individual circuit and operating fully loaded for only a short time, the losses in the reactors do not amount to much.

Reactors have been on the whole very satisfactory. There have been a few instances where cats have climbed the fence and, jumping around the reactors, have caused a flashover. The newer reactors have insulated cable, which practically eliminates trouble of this nature.

Los Angeles Gas and Electric Corporation—

We have had two 33-kv., 3-phase oil insulated reactors in use for four years now and have over 100 three-phase low-voltage reactors in service without any trouble of any nature. It is felt that the improved service and lower investment in circuit breakers prove their usefulness.

Section 4—New Developments

The manufacturing companies did not submit anything new in design that had not been covered in previous reports or elsewhere in this report.

Conclusion

The subject of oil leaks in transformers and regulators has been carried forward several years and some small progress is being made in eliminating this trouble, but much remains to be done. Reports of excessive noise due to worn regulator bearings are becoming very numerous. The use of reactors on the Pacific Coast is steadily increasing. Most of those companies not now using them are making provision for possible future use.

It is recommended that the work of this committee be continued next year.

*Starting Current for Induction Motors**

Results of a field investigation by member companies revealed that starting currents demanded by induction motors were far in excess of the limits set by 1923 N.E.L.A. rules. Resolutions were passed by the local subcommittee and by the national organization which have been forwarded to the manufacturers.

BEING alarmed at the excessive starting current demanded by induction motors available in the market, the member companies, two years ago, launched a field investigation to determine the exact status of the induction motor equipment operating on the several systems.

The report of the subcommittee which made this field check showed that many of the motors in operation required starting currents greatly in excess of the limits specified in the N.E.L.A. 1923 rules, and that most of those available in the market had the same fault.

The apparatus committee therefore decided to study the conditions and try to arrive at a conclusion as to what starting current demands the systems could handle without detrimental effect.

This study was carried on, due consideration being given to the statement from the manufacturers that satisfactory modern motors could not be developed which would have starting currents within the limit specified in the N.E.L.A. 1923 rules.

In response to communications directed to the Manufacturers' Association we were advised, after some delay, that a line of squirrel-cage motors would be developed that would have blocked rotor currents within the limits specified in the 1923 rules. The manufacturers demanded greater limits for line-starting motors, so that after much study and deliberation the apparatus committee approved the recommendation of the utilization subcommittee. The following resolution was adopted:

Whereas, during the past few years the capacities of the coast system have greatly increased; and whereas, the manufacturers have agreed to develop improved squirrel-cage motors with blocked rotor current values within the N.E.L.A. 1923 limits and claim that is is impossible to design suitable line-start motors within these same limits,

Resolved, that the N.E.M.A.'s guarantee for squirrel-cage motors to operate on reduced voltage starters that will comply with the blocked rotor current values as specified in the N.E.L.A. 1923 rules with improvements in other essential characteristics is accepted, with the understanding that no motor shall show a measured starting current in excess of the allowable blocked-rotor current for that motor as specified in the N.E.L.A. 1923 rules, when operating on the highest tap of the starting device.

Further, that the member companies will consider as acceptable line-start motors showing blocked rotor current values 25 per cent in excess of the values specified in the N.E.L.A. 1923 rules for motors of 50 hp. size and larger, motors of 40 hp. size and smaller to retain the blocked rotor current values specified in the N.E.L.A. 1923 rules.

After adopting the above resolution the committee decided that it would be well to continue the study for another year.

Copy of the resolution was forwarded to the Manufacturers' Association, N.E.L.A. headquarters, and to the chairman of the N.E.L.A. utilization subcommittee.

After repeated efforts to get an answer from the manufacturers, a substitute resolution was submitted to our committee by the manufacturers, as follows:

That the N.E.M.A.'s guarantee for squirrel-cage motors to operate on reduced voltage starters that will comply with blocked rotor

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* Report of utilization subcommittee, electrical apparatus committee, Engineering Section. E. J. Crawford chairman. A. W. Copley, H. H. Cox, C. B. Judson, D. J. Kelly, H. S. Lane, R. F. Monges, T. G. Myers, S. P. Russell, H. J. Schomberg, E. R. Stauffacher.

values as specified in the N.E.L.A. 1923 rules with improvement in other essential characteristics, is accepted with the understanding that no motor shall show a measured starting current in excess of the allowable blocked rotor current for that motor as specified in the N.E.L.A. 1923 rules *when operating on one of the standard taps of the starting device.*

That the member companies will consider as acceptable line-start motors showing blocked rotor current values 25 per cent in excess of N.E.L.A. 1923 values for motors of 40 hp. and 50 per cent in excess of N.E.L.A. 1923 rules for motors of 50 hp. sizes and larger, motors to 30 hp. size and smaller to retain the blocked rotor current values specified in the N.E.L.A. 1923 rules.

There was some doubt as to the proper interpretation to place on the change proposed by the N.E.M.A. regarding the current demand of squirrel-cage motors. On inquiry we found that they proposed that these motors should remain within the specified limits only on some intermediate tap of the starting device, but would take a greater current on the highest tap.

This appears contrary to the former information from the N.E.M.A. that they would develop squirrel-cage motors with blocked rotor current values within the limits specified in the N.E.L.A. 1923 rules.

After due consideration this proposed substitute resolution was rejected and the former resolution adopted by our committee re-affirmed.

Notice to this effect was forwarded to the Eastern bodies by your chairman.

The action of the apparatus committee was officially approved by the executive committee of the Engineering Section and notice of this approval forwarded to the president of the N.E.L.A. by the chairman of the Engineering Section.

Our stand having now been definitely established, there now remains for decision only what action the member companies shall take regarding installation on which the motor characteristics do not fall within the limits we have established.

In the meantime we have been informed that the apparatus committee of the N.E.L.A. passed the following resolution on Jan. 25, 1930:

Whereas, recent motor starting rules of the utilities allow starting currents for the same motor under different conditions of service, such rules cannot take the place to the manufacturers for design purposes, of the information included in the N.E.L.A. 1923 motor rules.

Resolved, that the N.E.M.A. be invited to join with representatives of the N.E.L.A. to suggest to the electrical apparatus committee what changes are desirable in the 1923 rules of the N.E.L.A. motor starting currents, viewed in the light of the past seven years' program in design.

Undoubtedly our view will have proper consideration, as all the bodies have been regularly informed of our conclusions. It would be well for our association to keep closely in touch with developments in the East.

HYDRAULIC POWER COMMITTEE REPORTS[2]

*Automatic Hydraulic Regulatory and Safety Devices**

This report is intended to cover such automatic regulatory and safety devices as are in use in hydro-electric developments as separate or distinct units in contrast to those which are found in automatic or semi-automatic plants and are more or less intimately associated with the automatic equipment for the operation of the plant. This latter class of automatic equipment, which is both regulatory and protective in nature, has been thoroughly covered in the report of the subcommittee on automatic hydro-electric plants published in the 1928 Proceedings of the Pacific Coast Electrical Association beginning on page 195, and will be still further covered by a subcommittee report of a like committee of the national hydraulic power committee.

There remains a distinct class of automatic equipments of a regulatory or protective nature which function as complete units in themselves. They may be found at remote points isolated from the power house proper, or may be located within the building itself. They have a certain definite purpose which is performed automatically and may properly fit in with the operation of a manually controlled plant or an automatic plant.

To be of value to the interested reader a report of this character must contain considerable detailed description. In order to keep the size of the report within proper limits, only a few of the suggested subjects have been treated. These, however, have been covered as completely as possible. It is suggested that further contributions be made next year and additional subjects covered so that we may finally have at hand a source of valuable information for the use of engineers and operators in the solution of their particular problems.

Automatic Safety Devices

Penstock Shut-off Valves—

ONE of the most important applications of automatic equipment of a protective nature is that of providing for the closure of the upper penstock valve in case of a penstock failure. Penstock failures are rare, but when one does occur the damage done by the released water is usually very severe. Equipment is destroyed and tons of debris are deposited at points which will make the removal expensive or possibly render further operation of the plant impossible. If the flow of water can be checked promptly, the damage will be reduced to a minimum. The added cost of this protection is a very small item in the over-all cost of the plant.

The prime requirement of such a device is absolute reliability. It is the last line of defense and must not fail. For this reason it must depend upon an unfailing source of energy for its operation, and nothing can replace the force of gravity. The supply to an electric motor may be interrupted just when most needed, and any mechanical device, such as a stressed spring, may fail for any one of a number of reasons. The force of gravity acting through an hydraulic medium is the most reliable and easily con-

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[2] Clinton de Witt, Pacific Gas and Electric Company, chairman. C. M. Mardel, Great Western Power Company, vice-chairman.
Great Western Power Company: R. E. Ballew, H. K. Fox, C. P. Rhine, C. P. Vetter.
Los Angeles Bureau of Light & Power: R. R. Robertson, C. C. Ruble.
Pacific Gas and Electric Company: E. A. Crellin, D. P. Dinapoli, W. Dreyer, J. R. Johnson, H. Keesling, B. N. Merritt, E. N. Murphy, L. O. Murphy, L. G. Roberts.
Pelton Water Wheel Company: E. M. Breed.
San Francisco Engineering Department: N. A. Eckart, P. J. Ost.
San Joaquin Light & Power Corporation: R. C. Denny, J. W. Jourdan, R. D. Likely.
Southern California Edison Company: S. F. Coghlan, J. F. Davenport, J. M. Gaylord, P. H. Gilbert, C. H. Holladay, Lloyd F. Hunt, R. B. Lawton, F. J. Mills, R. M. Peabody, K. A. Reeder.
Southern Sierras Power Company: C. L. Davis, E. J. Waugh, G. M. Wills.

* Report of subcommittee on automatic and safety devices, hydraulic power committee, Engineering Section. E. A. Crellin, chairman. S. F. Coghlan.

trolled device suitable for valve operation. Two sources of supply are available, the water in the penstock itself or an independent storage tank. The latter is the most desirable because it is independent of any loss of pressure head due to the increased flow of water through the penstock. Also, oil may be substituted for water, and danger from freezing eliminated. (This is an important consideration and every precaution must be taken to insure protection from freezing if the reliability of the equipment is to be maintained). A typical example of the application of such a device will serve to bring out the features involved.

The upper end of the penstock at the Eldorado power house of the Pacific Gas and Electric Company is equipped with a 72-in. diam. butterfly valve operated by means of an hydraulic cylinder. Cylinder pressure is obtained from a gravity oil supply stored in a tank on the hillside above the valve under a head of about 70 ft. Details of the valve and operating mechanism are shown in Fig. 1.

The control valve for the operating cylinder is a standard Pelton governor valve with special body connections and with pilot operated by a newly developed differential pressure relay, cross section of which is shown in Fig. 2. All stuffing boxes and consequent sliding friction which would impair the reliability of the device are eliminated by using Sylphon bellows. Upstream pressure taken through a a pilot tube connection is applied to the top of the relay piston while downstream pressure taken through an independent connection is applied to the bottom of the piston. As the areas under pressure on the top and bottom of the piston are identical, the force developed is a measure of the velocity of flow in the pipe line. Calibration and adjustment permit the device to operate at any desired excess flow.

A novel feature of the mechanism is the toggle mounting of the relay stem so that the uplift force diminishes with downward travel. Thus any operation once started will follow through for a full stroke. This is an essential characteristic of any such device. Another important feature is that the operating piston is subject only to the differential pressure and not to the total pressure. One of the great objections to previous developments of this type has been the fact that the areas were not identical, with a result that the total pressure was a factor, thus giving false indications during pressure surges in the pipe line and even

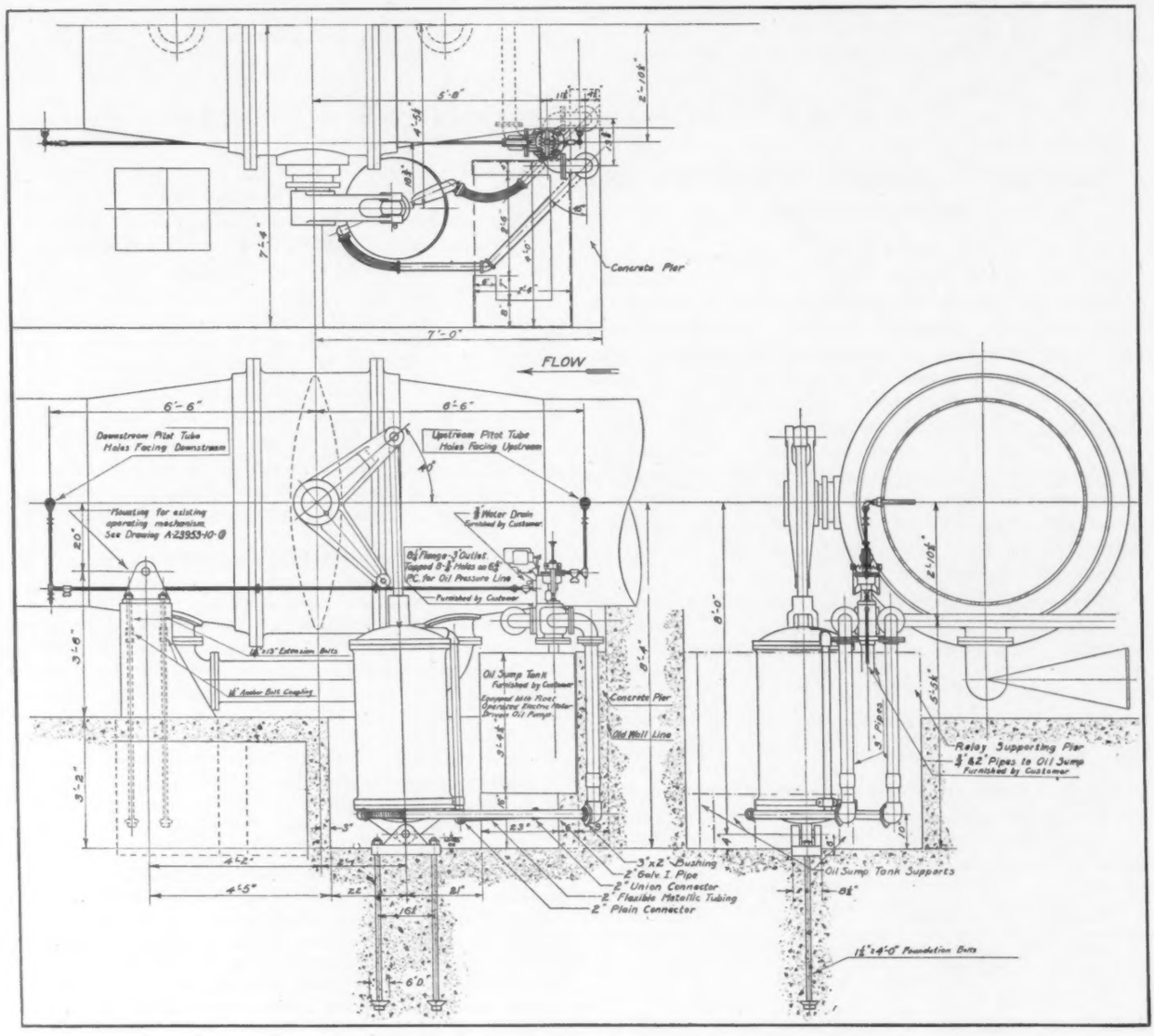

Fig. 1. Automatic oil pressure control for 72-in. butterfly valve.

bringing about shut-down in case of sudden load change while the actual pipe line velocity was well below that of full load.

The solenoid is for emergency or test operation from the power house. An open circuit rather than closed circuit system is used, as it is undesirable to bring about shutdown in case of failure of the pilot circuit. Energizing the solenoid exhausts the lower chamber to drain, thus giving the shut-down signal. Movement of the butterfly valve is indicated at the power house by a separate electrical indicator. During tests it is customary to operate the solenoid for just a short period to see that the mechanism responds, allowing it to reset immediately when the circuit is broken, providing of course that meanwhile the butterfly valve has not closed sufficiently to prevent restoration of downstream pressure.

An interesting safety feature of the device is the provision of having the upstream pilot tube connection taken from above the butterfly valve while the downstream is from below. This prevents automatic operation of the relay, following butterfly valve closure, until the downstream pipe line is up to full pressure. This prevents any possibility of the butterfly valve opening automatically into an empty pipe line. A photograph of the control valve assembly is shown in Fig. 3.

Obviously an air valve of generous area should be installed on the downstream side of the valve to prevent formation of a partial vacuum and possible destruction of the pipe line below when the water drains as a result of the emergency, bringing about excess flow and shutdown.

The foregoing description has applied to a butterfly valve installation. It may be applied to any hydraulically operated valve. The butterfly valve, however, is the ideal shut-off valve for the upper end of the penstock. It closely approaches a self closing valve because after passing the first five degrees from the full open position there is a positive closing tendency until it has made a large percentage of the closing stroke. During the remainder of the stroke the journal friction becomes a large factor. The hydraulic operating cylinder acts as a dash pot during a part of the closing stroke and furnishes the necessary force to complete the closure.

In the installation described above, the oil from the operating cylinder exhausts into a sump tank. A small motor driven pump which is float controlled automatically empties the sump when it has filled to a predetermined level and returns the oil to the gravity storage tank on the hillside above the valve.

Other methods of utilizing the increased velocity of flow to cause valve closure are in use. One type employs a paddle placed in the stream and pivoted in a dome outside the pipe. When the velocity of the water exceeds a definite prearranged amount, the reaction on the paddle due to the velocity head overcomes the balance weight and gives the closing impulse. A mechanism of this type using a gravity actuated disk in the butterfly valve is shown in Figs. 4 and 5.

Automatic Sectionalizing of Breaks in Very Long Pipe Lines

An interesting application of bypass and sectionalizing valves has been made on the Mokelumne pipe line of the East Bay Municipal Utility District serving water to the City of Oakland. This pipe line is about eighty-four miles

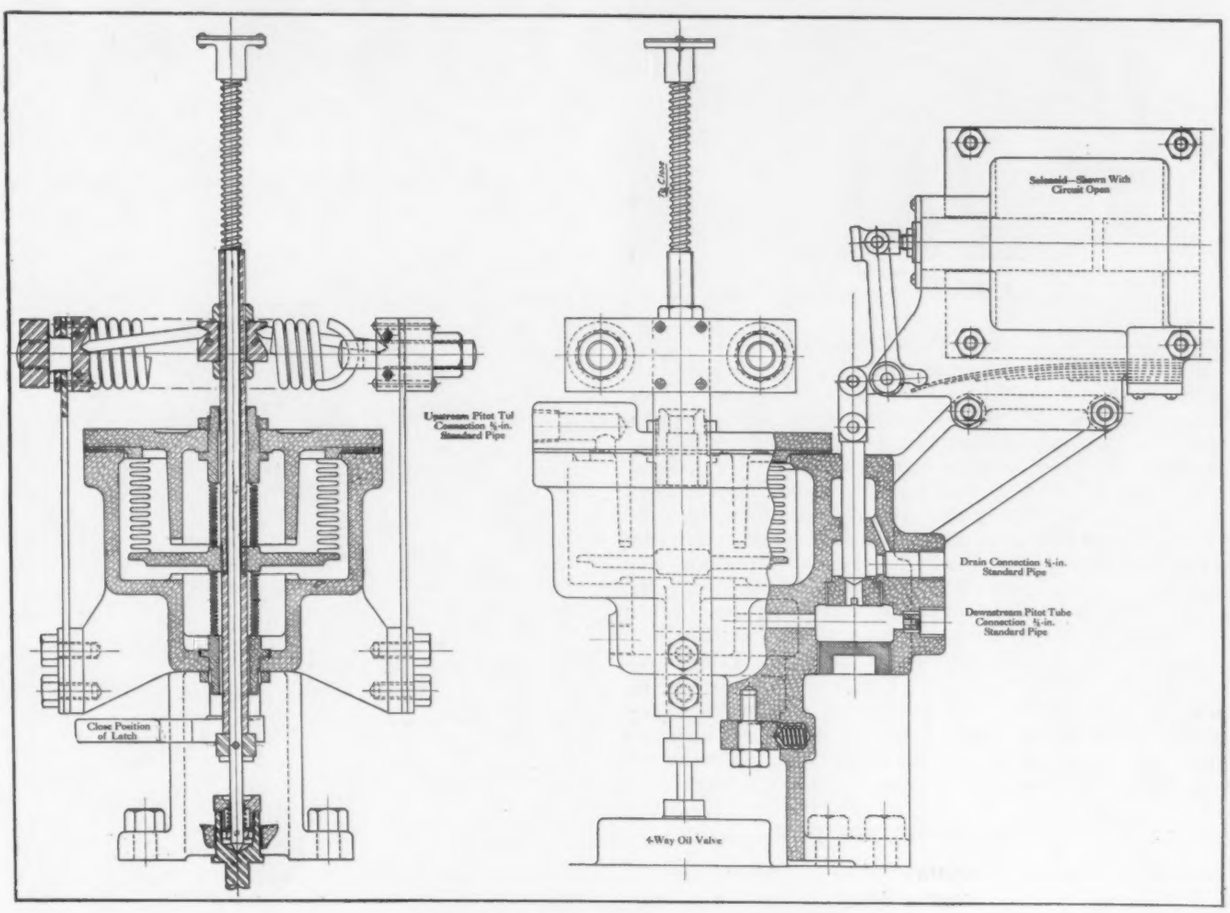
Solenoid—Shown With Circuit Open
Upstream Pitot Tube Connection ¾-in. Standard Pipe
Drain Connection ¾-in. Standard Pipe
Downstream Pitot Tube Connection ¾-in. Standard Pipe
Close Position of Latch
4-Way Oil Valve

Fig. 2. Differential pressure relay valve assembly.

in length, 65-in. inside diam., and is not designed for full static head. The special sectionalizing valves are located at approximately twenty-mile intervals at natural waste ways where the water can be discharged conveniently without damage to adjoining property.

The assemby consists of an electric motor-operated butterfly valve located at the throat of a venturi section in the pipe line, combined with a 24-in. inlet, pilot controlled, hydraulically-operated relief valve which connects to the pipe line a short distance upstream of the butterfly. Excess velocity created by a major break downstream actuates the differential control, causing the electric motor operated butterfly to make a complete closing stroke. The relief valve opens inversely with the butterfly closure, protecting the upstream conduit from objectionable water hammer and discharging the water from the upstream pipe into the waste way. Due to the fact that the pipe line is not designed for full static head, the relief valve does not have any self-closing feature with dash pot control, but continues to waste water until the flow is shut off at the upper end of the pipe line. A self-closing feature can be readily added for the conservation of water if pipe line conditions are such as to withstand the pressure incidental to full static head. Practically all of the equipment used in this installation, is standard and the features well known. The application, however, is unique and may find further application where similar conditions are met. A brief write-up of the equipment was contained in the September 27, 1928 issue of Engineering News-Record.

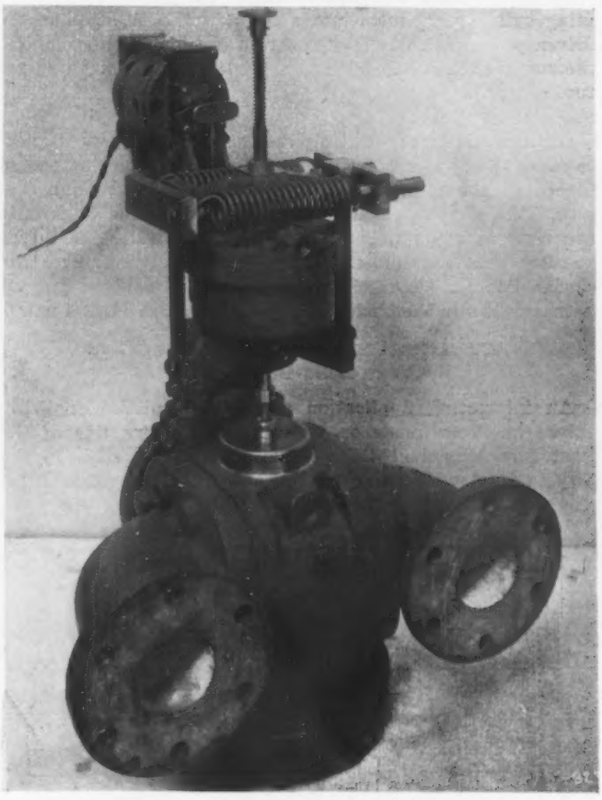

Fig. 3. Control valve assembly.

Automatic Regulating Devices

Automatic Control of Discharge Through a Dam—

It frequently happens that a power development is constructed on a river, the flow of which must be maintained at normal value for irrigation or other purposes downstream from the power house. If this condition holds, some regulatory device must be installed to permit peak load operation of the plant. The usual method is to construct an afterbay dam which will impound the water passed through the units during the hours of peak load operation and permit of its uniform release throughout the day.

Two main elements are present in the problem of designing equipment for this service. First the flow in the river must be maintained constant throughout the twenty-four hours of any given day, and second, the device must be cap-

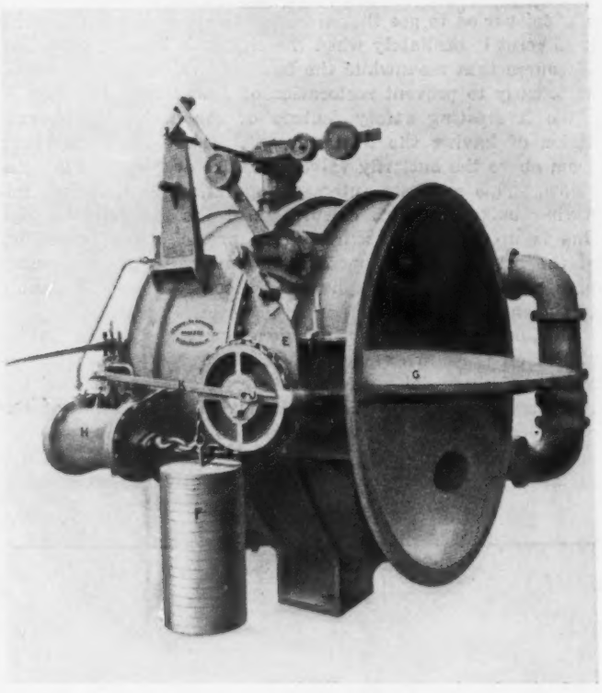

Fig. 4. Weight-operated self-closing balanced disk valve.

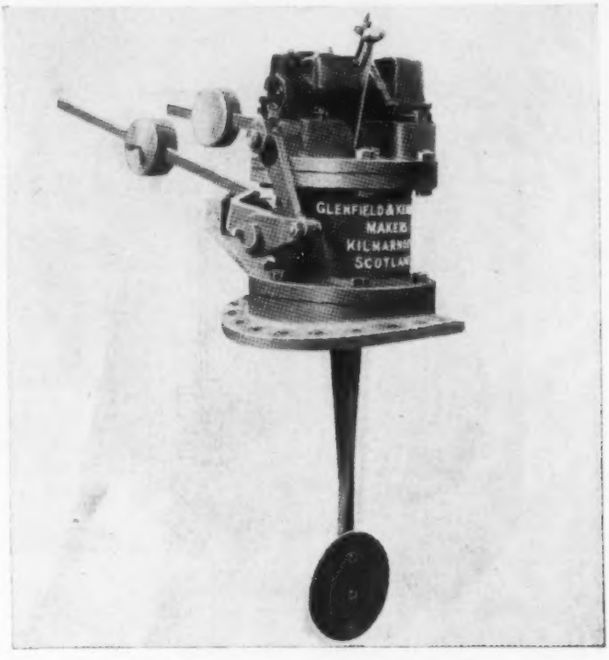

Fig. 5. Type of trip gear applied in connection with electrically operated valves.

able of adjustment to care for the natural variations in river flow from day to day or week to week or longer periods. With a fluctuating water level behind the afterbay dam caused by the varying load in the power house, a constant readjustment of discharge gate opening is necessary to maintain constant river flow. Automatic control is essential in such a service.

A typical installation will illustrate the features necessary for the proper functioning of such a device. Modifications to suit special conditions will suggest themselves, but the basic principle will remain unaltered. The device, which is shown diagrammatically in Fig. 6, consists of three main elements, namely, the float mechanism, the relays, and the gate with its controlling motor and contactors. The float mechanism is installed in a float well, located in a calibrated section of the stream where the depth of water corresponding to a definite flow can be determined.

The float mechanism consists of two sensitive, single-pole float switches which have an approximate travel of the operating lever of ½ in. between the full open and full closed position. The floats are mounted on a yoke so that they many be raised or lowered to maintain any desired water level in the stream. This provides for seasonal fluctuations in normal river flow. As illustrated in Fig. 6, this raising and lowering is accomplished by means of a screw and handwheel, the position of the screw relative to the handwheel indicating the flow. Hand control of seasonal fluctuations will usually suffice as such fluctuations are not rapid and need not be compensated for oftener than once in a day, week or month depending upon conditions. If more frequent change is necessary, or if a remote control is desired, the handwheel may be replaced by a motor-driven gear wheel and a simple electrical control system installed.

Under normal conditions, float switches "C" and "D" are open. If the discharge through the dam is excessive, the rise in level will cause switch "C" to close and relay "B" is energized. Relay "B" remains closed while switch "C" is closed and energizes tapping motor "M." After the tapping motor has been energized the main contacts "K" close and energize relay "E." This relay completes the circuit to the gate motor contactor and causes the gate to close, thus reducing the discharge.

The tapping motor or its equivalent is an essential feature of the system. In the installation described the tapping motor consists of a Warren motor, two sets of contacts and a cam which has four risers. The cam which actuates the contacts is driven by the motor at the rate of one revolution per minute, thus making four contacts per minute. One set of contacts "I" is used as an interlock and is wired in parallel with the contacts of relay "B" which controls the

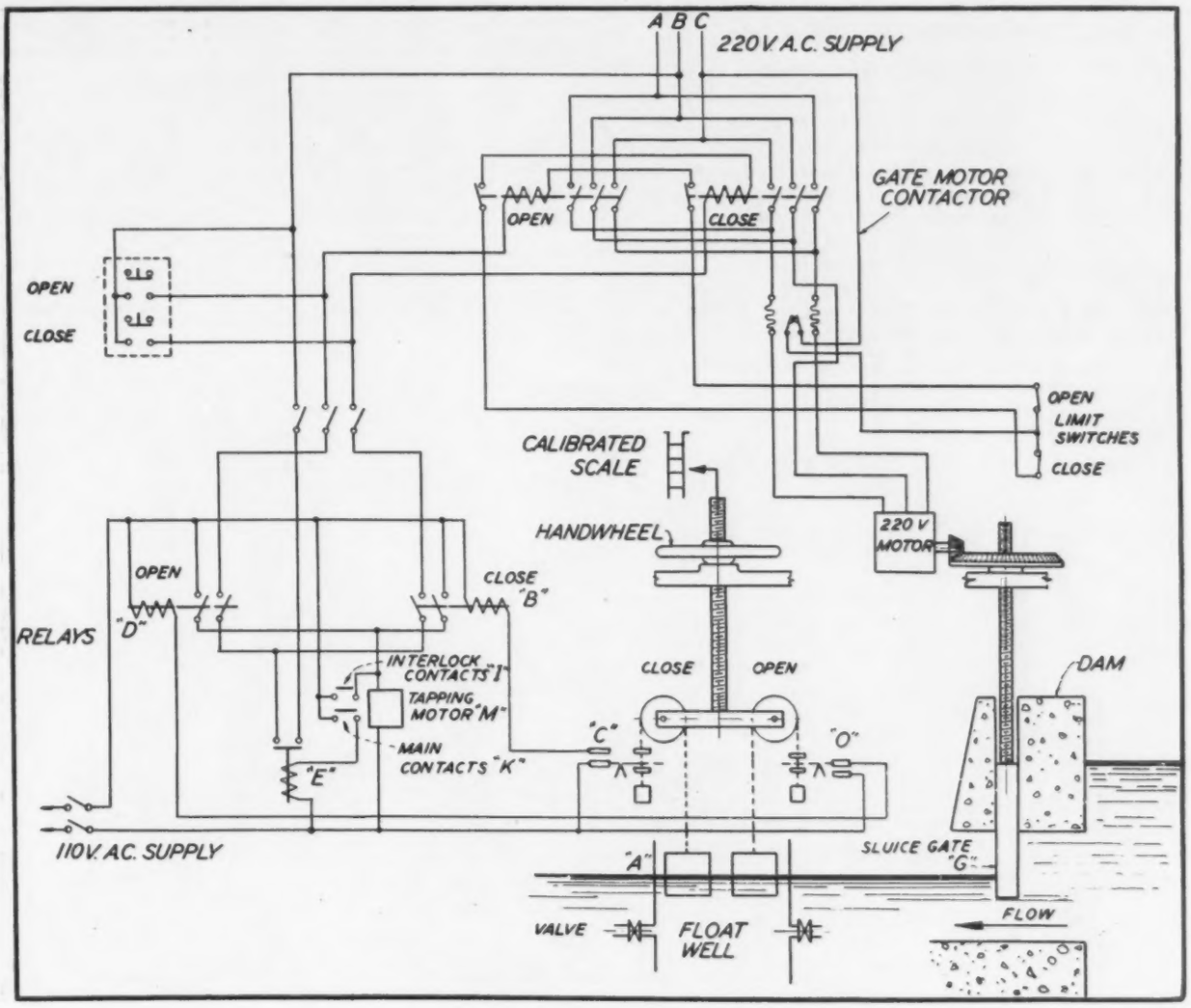

Fig. 6. Automatic control equipment of gates.

motor. The interlock contacts "I" should be adjusted so that they will close before and open after the main contacts "K." This arrangement prevents the motor from being stopped when the main contacts are closed. The tapping motor makes four contacts per second and the duration of each contact may be adjusted from 0 to 5 seconds. When the main contacts "K" of the tapping motor open, relay "E" is de-energized and the gate motion stopped. If, about 15 seconds later, the level at "A" has not been restored to normal, switch "C" will still be closed and the main contacts "K" will again close and move the gate another small increment. The operation will continue until the level at "A" is restored to normal at which time switch "C" opens and the gate movement ceases.

The main function of the tapping motor is to cause the gate to move a small increment at a time until the proper level is restored. It resembles in some respects the dashpot restoring device on a governor which prevents overtravel of the gates on a turbine. In a similar manner the tapping motor prevents over-travel and hunting of the discharge gate.

A falling water level in the stream reverses the process described above and closes float switch "O," thus opening the discharge gate sufficiently to restore the level to normal.

The equipment described above has been in operation for more than a year and has proven thoroughly reliable and satisfactory in holding the river flow constant at its normal rate regardless of the peaking operations of the plant and the fluctuating levels behind the afterbay dam.

Automatic Radial Gates

The automatic radial gate has many applications for the control of water flow, and a description of the operation of a typical gate together with brief mention of a few applications will present the subject in sufficient detail to permit studies of the suitability of the equipment to meet the requirements under consideration by the reader.

The California Corrugated Calvert Company has designed an automatic gate which is illustrated in Fig. 7. The method of operation so as to maintain constant upstream water level is also a part of the illustration, and further description of the gate and that particular application will be unnecessary. Many gates of this type have been installed and are giving thoroughly reliable and satisfactory service.

How the Automatic Control Gate is Operated

By means of set screws, the sheave wheels (D-D) and (R) are fastened to the shaft (E). This shaft is made of standard black pipe (see details elsewhere) and revolves in roller bearings (G). The steel cables (C-C) are wrapped twice around the sheave wheels (D-D), in order to prevent slippage. One end of each of the cables is fastened near the bottom edge of the gate, while the other ends are fastened to the weight (F). This weight is considerably heavier than the gate. The steel cable (H) has one end fastened to, and is wrapped several times around the sheave wheel (R). The free end, running on the same side of the shaft as that on which the gate is suspended, is fastened to the bucket (I), which swings freely in the well (J). The bucket is partly filled with water so that it will counteract the weight (F) and keep the gate in a closed position.

The well is equipped with a telescoping pipe (M), the upper end being provided with a funnel (L) in order to obtain a maximum entrance area for the water. The pipe (M) may readily be adjusted by means of a handle bar (N). An outlet pipe (Q) is placed below the minimum downstream water level. A flush-out valve (P) is placed near the bottom of the well for cleaning purposes.

Where flashboards are required, it is good practice to place them on each side of the gate, as shown. This will prevent the backlash from the undershot radial gate from damaging the canal bank.

How Constant Upstream Water Level is Maintained

I. Assuming that the water is let into the canal, and since the gate and the bucket combined are heavier than the weight (F), the gate will therefore be in a closed position.

As the canal is filled, the water eventually overflows the top of the funnel (L), flowing into the well (J) and out of the pipe (Q). But as the water continues to rise the intake of the funnel becomes greater than the outlet of the pipe (Q), since the inlet pipe (L) is greater than the outlet pipe. The water therefore rises in the well (J), reaches and partly submerges the bucket, thus decreasing its downward pull until the pull on each side of the shaft (E) becomes equal. As the water continues to rise, the weight (F) imparts a revolving motion to the sheave wheels (D-D) and raises the gate (B), permitting a portion of the water to escape. The rate of motion of the gate is equal to the rate at which the water in the well rises.

The gate continues to rise until it permits sufficient water to escape to cause a drop in the upstream water level, which in turn diminishes the flow over the funnel and causes a drop in the water level in the well (J), gradually lowering the gate until it permits just enough water to pass to maintain a certain constant head above the top of the funnel. When this head is reached, the whole mechanism remains in a state of equilibrium, but will readily respond to any fluctuation in the upstream water level. If the water level commences to drop, as would be the case when the laterals are being opened, less water runs over the funnel. The water level in the well drops and a consequent drop of the gate retains the same amount of water as is being drawn through the laterals, thereby maintaining an approximate constant water level in the canal. If the water level commences to rise, as would be the case while the laterals were being closed, or as the result of a cloudburst, more water runs over the top of the funnel, the water in the well rises and a consequent rise of the gate allows the excess water to escape. The water in the canal remains practically constant.

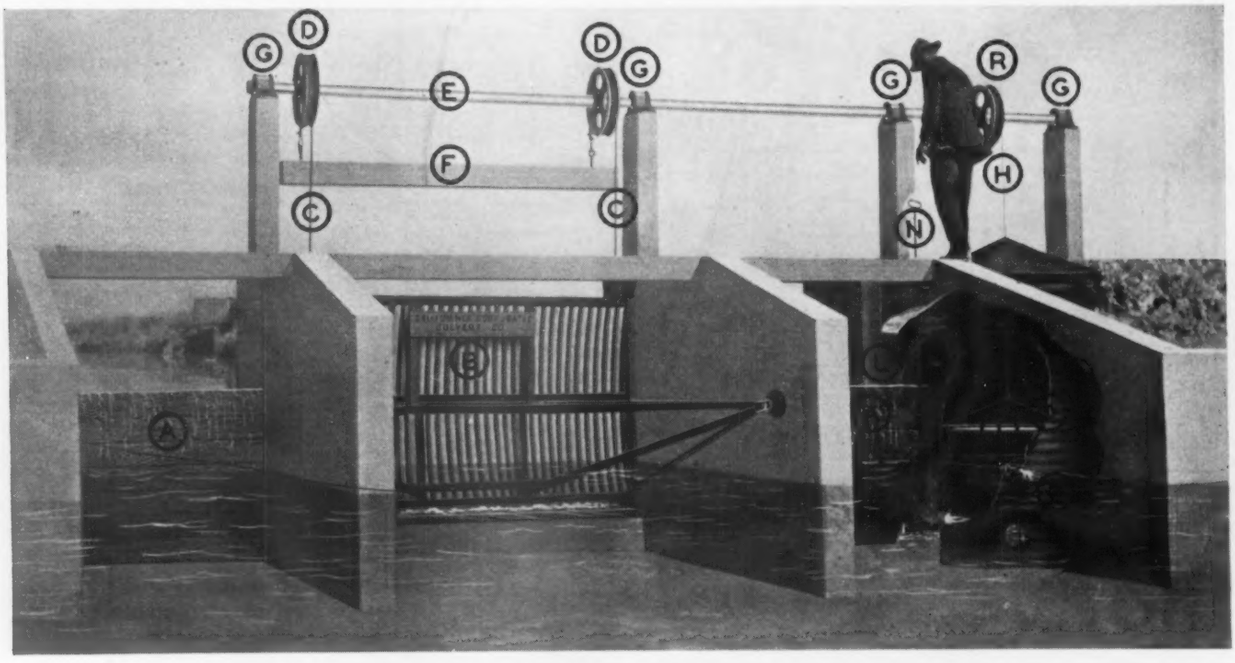

Fig. 7. Automatically controlled gate which maintains upstream water level.

A unique application of the principle was made at the Spaulding power house No. 3, of the Pacific Gas and Electric Company. This plant contains a single turbine-driven generator unit discharging water into Lake Spaulding storage reservoir. The water level in the lake varies over a wide range as storage water is withdrawn, and it was constantly necessary to build a weir in the tail race in order to maintain a draft tube seal on the turbine at times of low water in the lake. As the load on the turbine increases, the depth of the water over the weir increases, due to the increased water flow, and with increased tail water elevation the effective head on the turbine is reduced and output is reduced correspondingly. An automatic radial gate was installed in one end of the weir and arranged to maintain a constant tail race water level under all load conditions. This gain in head in some turbine installations will permit of sufficient additional kw.-hr. output to more than justify the cost of the gate which is in itself simple and relatively inexpensive.

Another application of this type of gate with modifications is in long canals where the runoff from small tributary streams is fed into the main canal. At times of excessive runoff these small streams may make an excessive delivery to the main canal. The automatic radial gate in this case would be installed across the canal and used for downstream water level control, with an upstream spillway to carry off the excess water. It may also be installed in the wall of the canal as a waste gate and operated to prevent the water in the canal from rising beyond a safe level.

One installation has been made at Colgate forebay using one gate as a check gate under downstream level control in which the check gate closed when the downstream dropped beyond a predetermined elevation, it being assumed that the drop in level was occasioned by a break in the penstock. A second gate was installed as an automatic waste gate for disposing of the flow in the conduit, as it was not practicable to raise the water surface in the wood flume to spill over an open spillway.

Other adaptions can probably be made, the above being a few examples of installations which have actually been constructed.

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*Automatic Frequency Control in Hydro-Electric Plants**

This report contains a discussion of the need for maintaining an exact frequency on power company systems and the means now in use to achieve that end. Several changes in practice made during the past year are recorded and a recommendation is made for an ideal automatic frequency control system.

THERE are now three real conditions that require exact frequency control on power companies' systems. First, certain industrial processes and methods require an exact frequency. Second, the complication of systems being interconnected requires exact frequency control to keep the load supplied over tie lines to a constant value. Third, the increasing use of synchronous clocks requires an exact frequency for correct time.

In order to keep the frequency of a system within narrow enough margins for the above conditions, a very close regulator or speed controller is required. The present mechanical governors have been unable to regulate as close as desired. Therefore, it is necessary to use super-refined speed control to meet this demand. There have been two methods used for some time but during the last year very many changes have been made in both so the very latest arrangements of these schemes will be included here.

* Report of subcommittee on automatic frequency control, hydraulic power committee, Engineering Section. Lloyd F. Hunt, chairman.

Method I

Automatic Frequency Controller—Proportional Step Type—

Fundamentally the purpose of the equipment is to control frequency within relatively close limits by direct connection of a controller to the governor regulating motor on a steam or hydro-turbine. The controller is of a proportional step type which automatically sends out an impulse to the turbine governor regulating motor proportional to the frequency deviation from the control point. If frequency is below a definite amount, the controller will transmit an impulse to the regulating motor of a duration and direction suitable to cause the governor to speed up the turbine and bring the frequency to the control point within close limits. The converse applies if frequency is high. Since the controller operates in steps proportional to the frequency deviation from the control point, there is no tendency for the control to overtravel or "hunt."

The control point on an instrument adapted for normal 60-cycle operation may be adjusted over a range from 59 to 61 cycles. This adjustment can be made at any time to overcome any slight cumulative frequency error and hold a correct average as indicated by a synchronous clock.

In a typical installation the "raise," "lower" and "common" leads from the controller are connected through suitable relays to the turbine governor regulating motor. If there are several turbo-generators in the power station, the automatic control can be placed on the largest machine and the others will naturally keep in synchronism with it so that the effect will be sufficient to control the whole station and possibly the whole system. When the control is connected to a single turbo-generator and the frequency is at the normal point, the load should be somewhat below full generator capacity so that there is a leeway for governing.

Fig. 1 is a reproduction comparing two frequency charts taken from the same recorder on the same power system under hand regulation of frequency and under automatic frequency control of the proportional step type.

The details of control equipment are shown in wiring diagram, Fig. 2. By comparison with the circuit diagram of our widely used frequency recorder, it will be noted that the same impedance bridge circuit is employed. Using this circuit, calibrations are accurate and permanent. Temperature coefficient and usual voltage vibrations are negligible.

The mechanical parts of the controller are identical to those that have been employed for years in the proportional step temperature controllers in installations where absolute dependability is required of the instruments. Fig. 3 illustrates the instrument with case closed.

In the foregoing description the connection of only one turbo-generator to the controller has been considered. If the station or system connection is of such a nature or proportion that one turbo-generator cannot handle the load fluctuations to maintain frequency, two or more machines may be connected in parallel to a single controller. In this case however it will probably be found necessary to adjust for the differences in characteristics and sensitivity of the turbine governing mechanisms. This adjustment can easily be made by inserting proper resistances in some of the individual control circuits to equalize the effect of the control impulse on all turbines.

In addition to this description of the frequency control equipment, an example of its practical application may be of interest. A frequency controller of this type has been in operation for some months at the Wallenpaupeck Station of the Pennsylvania Power & Light Company. This is a hydraulic station. Load fluctuations are particularly active

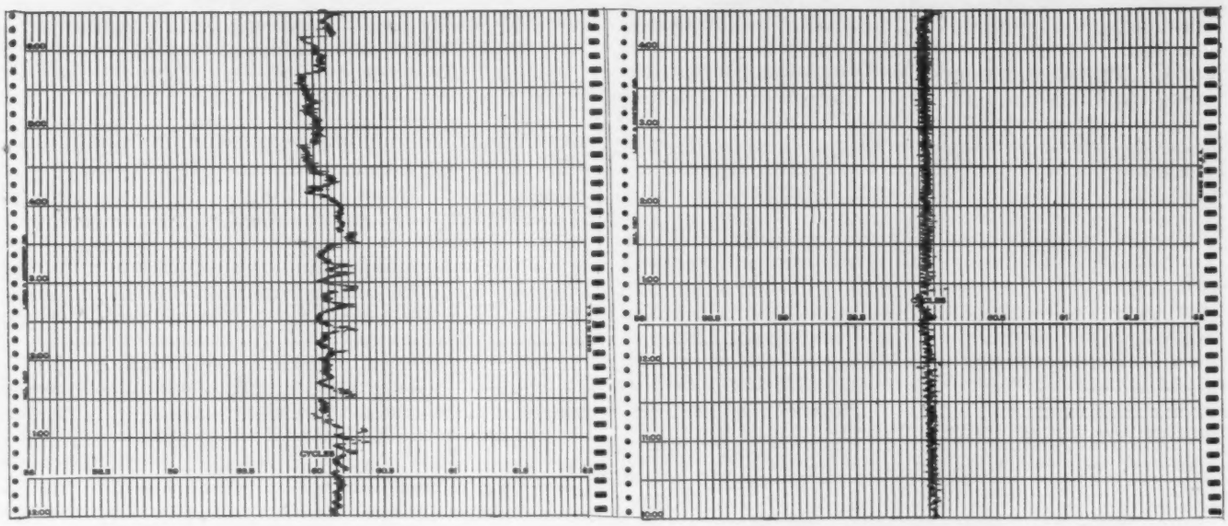


Fig. 1. Comparison of frequency of a large power system under manual and under automatic control. These charts were made by a frequency recorder with a range from 58 to 62 cycles. Charts are nominally 10-in. wide. Accuracy is guaranteed within plus or minus 0.1 cycle.

on this station and prior to the installation of the frequency control equiment it was extremely difficult to regulate frequency. It is now reported that frequency is being controlled to better than 0.1 of a cycle continuously and averaging within plus or minus 0.05 of a cycle. There is no doubt that frequency control within close limits on a steam station could be more easily obtained than on this hydraulic station, due to the fact that steam turbine governors are usually much more sensitive than hydro-turbine governors.

Flat Frequency Control

The automatic frequency controller as described above is one of the original developments in this field and is used to maintain constant system frequency in conjunction with manual distribution of load. It has been used particularly in simple installations where it is possible to regulate system frequency with a single generator. If at any time the load variations become too great for the single generator to carry and still maintain the desired frequency, it is then necessary to rebalance the load manually as is done in the ordinary manual operation of the station or system. The manner in which this controller functions is outlined in greater detail in the preliminary description.

Due to very recent developments which are outlined here, the information in the preliminary description must be modified. The combination of automatic frequency and automatic load distribution control takes advantage of the proportional-step controller but requires some changes in design. Briefly, the controller described in the preliminary description as now supplied is equipped with only the motor driven contact mechanism and the actuating galvanometer. This contact mechanism is in reality a motor driven interrupter the duration of the contacts in which are practically proportional to the amount of adjustment required to return the frequency to the desired value. This mechanism is identical with that employed in all of this manufacturer's recording mechanisms, with the exception that the rotating cams are employed for high and low control contacts. In order to give a clearer conception of this construction Fig. 4 attached shows printed figures in perspective of the mechanism and shows the proportional stepping mechanism under discussion excluding the driving motor. The cams, 6E and 6L, Fig. 5, are rotating normally at a speed of 27.5 r.p.m. This speed may be changed to a different value if conditions require it. Assum-

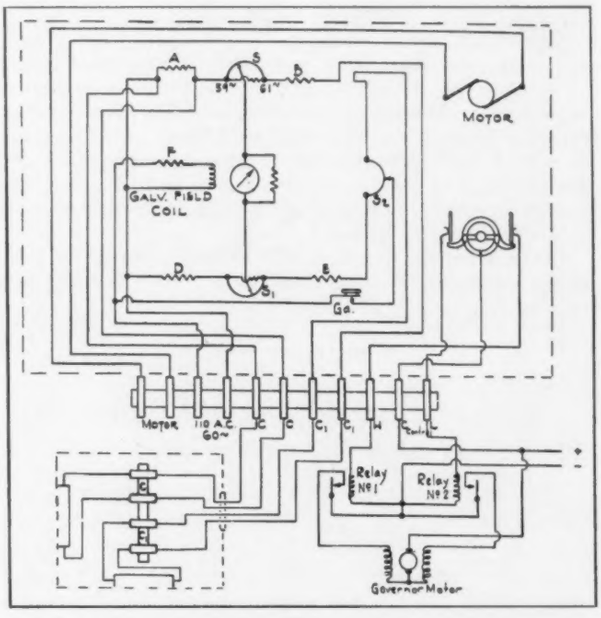


Fig. 2. Wiring diagram, automatic proportional-step frequency controller.

ing for example that system frequency is being controlled at a predetermined value of say 60 cycles, the galvanometer pointer will rest in the center of the notch (see Fig. 5) and therefore no impulses will be sent to the governor mechanism. However, if the frequency deviates from the control value the pointer will be pinched as shown in Fig. 4 causing one of the cams to strike the Yocker arm 2, making a high or low contact. As previously explained, the mechanism is so designed that the duration of the impulse thus formed corresponds practically to the amount of adjustment required —that is, the mechanism tends to make the generator change speed in the amount required by proportional steps.

Two separate pieces of equipment are supplied with the contacting mechanism. First, a frequency load setter containing the calibrated load, frequency and bias dials; and,

second, a steel container with condensers, filter and a potential transformer. Obviously the purpose of this arrangement is to provide flexibility so that a complete control system may be installed later if it is desired to employ only flat control in the beginning and furthermore in order to use the same mechanism for both load and frequency control.

Automatic Frequency Control With Automatic Load Distribution Control

With larger installations where there are a number of generators in the station, all of which may be required in regulating system frequency, the flat frequency controller is not entirely satisfactory, since distribution of the load among the different generators manually becomes difficult, especially if the variations in the system load are numerous and rapid. Furthermore, conditions may be such that one generator will assume a greater or lesser proportion of the load fluctuations, due to difference in governors, causing serious unbalance of load. The resulting fluctuations in speed will not provide close frequency regulation under these conditions. For these reasons we have developed additional apparatus which will not only distribute the station load among different generators but will also maintain constant frequency at the same time if desired. Two systems have been developed, one which distributes the load proportionately between the generators in the station and the other which distributes the load economically between the generators, both maintaining constant

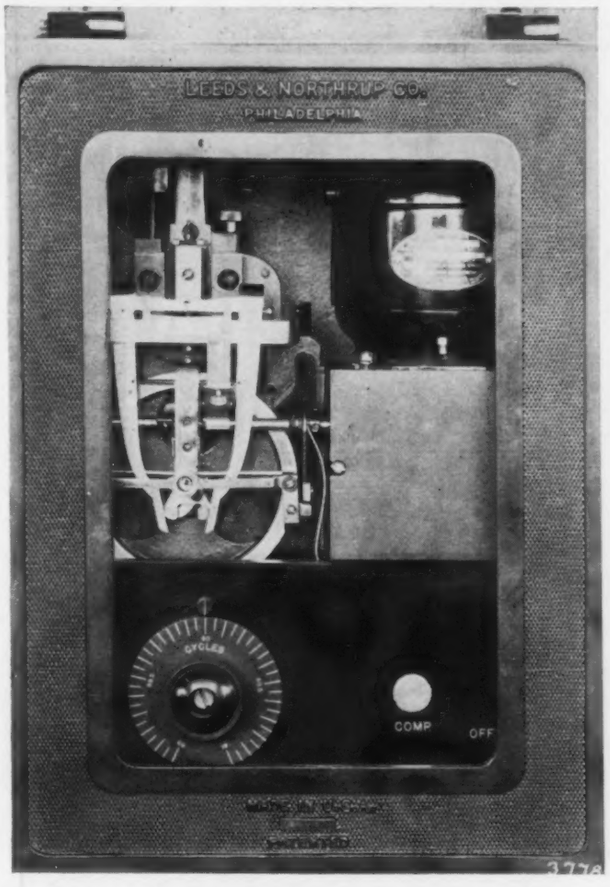


Fig. 3. Automatic proportional-step frequency controller with case closed.

frequency. The proportionate load distribution system is applied when the efficiency characteristics of the generators are practically identical. In installations where the efficiency characteristics of the individual generators differ widely, the economic distribution of load system is recommended.

Assuming that all generators in one station are to be automatically controlled and that all generators in the station have practically identical efficiency and characteristics, this system of frequency control with automatic proportional load distribution control will enable the station to be operated in any one of the following ways:

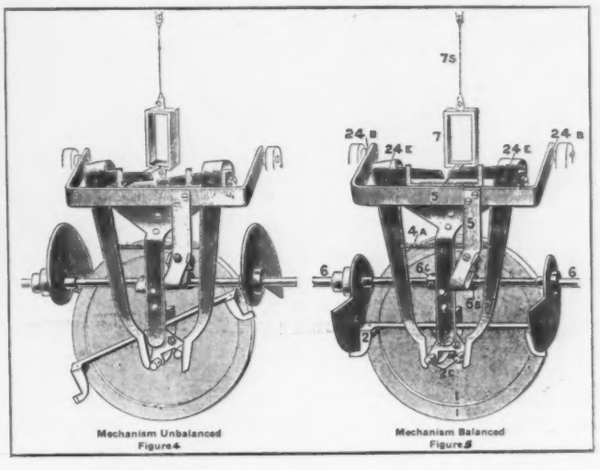
1. Frequency control on the entire station with automatic proportionate load distribution among the different units.
2. Base load control on the station without regard to frequency and with definite load distribution among the different units.
3. Biased load frequency control on the stations.
4. Operation with practical combinations of the above, that is, the station might be operated with automatic frequency control on one unit and base load maintained on the others.

The way in which these different types of control are obtained is outlined as follows:

Flat Frequency Control on the Station With Automatic Proportionate Load Distribution Among the Different Generators.—In order to control in this manner, each generator in the station is provided with a proportional-step frequency-load controller mechanism. The appearance of this controller is as shown in Fig. 3. This mechanism is the same as that described under previous section.

The measuring circuits for both frequency and load control are mounted in a separate container equipped with frequency, load and load bias dials, which is called the load frequency setter. For frequency control the same basic measuring circuit is employed as in the frequency recorder. This circuit consists of an impedance bridge, the balance of which is dependent upon the instantaneous frequency values.

One generator in the station is selected arbitrarily as a pilot controller to regulate frequency by the proportional-step controller connected to it. The rotary selector switch provided with the complete equipment would therefore be set at (F) "frequency" for this generator. This procedure might swing the load on this generator a considerable amount. In order to arrange the controller equipment so that each generator will share proportionately in the frequency regulation, a shunt is connected in the current transformer circuit in one phase. The potential drop across the shunt in the generator which has been selected as a pilot controller is opposed to another potential drop across the shunt in a second generator through the galvanometer of the proportional-step controller mechanism. When these two potentials are equal, that is, when the loads on the generators are equal, assuming equal capacities for the generators, the controller causes no action. If the potentials become unequal the second controller



Figs. 4 and 5. Recorder mechanism in balanced and unbalanced position.

will regulate the generator through the governor mechanism until the second generator takes on the same load as the pilot generator. This same action is extended to any other generators under automatic control in the station. The rotary selector switch on all generators participating in the load fluctuations would be set at P-L, "proportionate load."

Although the potential drop across each of the shunts in combination with the current transformers on the various generators is used as a measure of the total current output of an individual generator, this value is introduced into the control circuit in such a manner that only the power component is effective. In other words, the controller is operated fundamentally by its actual measurement of power in kilowatts.

Base Load Control on the Station With Definite Load Distribution Among the Different Generators.—With this arrangement a so-called "hand operated load setter" is furnished for use in connection with the controller on each generator. If for example it is desired to hold a base load of 120,000 kw. on a station having six machines all alike, each individual load setter would be set at 20,000 kw. and each machine would then take its share of the total load. This is accomplished by the use of an a.c. potentiometer in each load setter, that is, in each load setter there is a slide wire fed from an a.c. source so selected as to have a certain definite phase relation with respect to the power component in the drop across the shunt in each generator current transformer circuit. In other words, the emf. on this slide wire may be made proportional to the load desired on the machine and this emf. is then opposed to that of the shunt in the corresponding generator. If the load of the generator is then above or below thas value, the galvanometer of the controller deflects one way or the other and in turn operates the relays controlling the synchronizing motor on the corresponding turbine. For this control the rotary switch is set at I-L, "independent load."

Biased Load Frequency Control on the Station.—With this arrangement the controller on each generator is operated as a frequency controller, the calibration of which is varied a small amount by an increase in load on its corresponding generator. When controlling one station alone this feature may be of no particular value in itself, but when it is desired to control frequency on an entire system with several stations participating it will have certain advantages.

The result of operating a generator on biased load frequency control is that under stable conditions the generator is operating at a fixed load. When the frequency of the system fluctuates due to changes in load the generator with biased control assists the pilot generator to assume such changes, but while the system is being adjusted again to a condition of equilibrium by the pilot generator the generator with the biased control is returning to the load point at

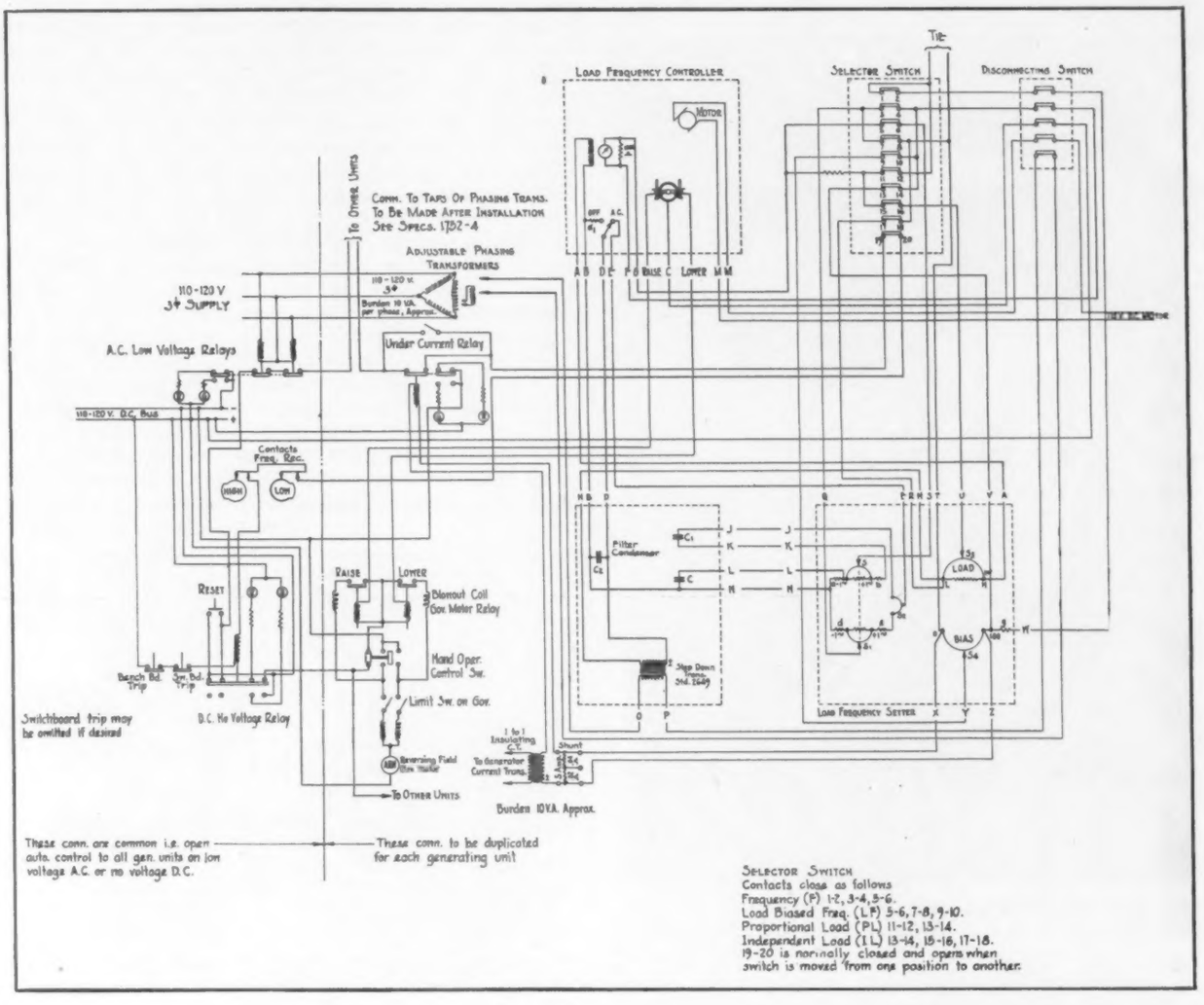

Tie
Load Frequency Controller
Selector Switch
Disconnecting Switch
Motor
To Other Units
Comm. To Taps Of Phasing Trans. To Be Made After Installation See Specs. 1702-4
Adjustable Phasing Transformers
110-120 V 3φ Supply
A.C. Low Voltage Relays
Under Current Relay
110-120 V. D.C. Bus
Contacts Freq. Rec.
High
Low
Reset
Raise
Lower
Blowout Coil Gov. Motor Relay
Hand Oper. Control Sw.
Limit Sw. on Gov.
Bench Bd. Trip
Sw. Bd. Trip
D.C. No Voltage Relay
Switchboard trip may be omitted if desired
Reversing Field Gov. Motor
To Other Units
1 to 1 Insulating C.T.
To Generator Current Trans.
Shunt
Burden 10 V.A. Approx.
Filter Condenser
Step Down Trans. 2nd. Stage
Load
Bias
Load Frequency Setter
These conn. are common i.e. open auto. control to all gen. units on low voltage A.C. or no voltage D.C.
These conn. to be duplicated for each generating unit
Selector Switch
Contacts close as follows
Frequency (F) 1-2, 3-4, 5-6.
Load Biased Freq. (LF) 5-6, 7-8, 9-10.
Proportional Load (PL) 11-12, 13-14.
Independent Load (IL) 13-14, 15-16, 17-18.
19-20 is normally closed and opens when switch is moved from one position to another.

Fig. 6. Detailed wiring of control equipment for one unit, proportional load-frequency control, with rotary switches.

which it was originally set by taking load from or delivering load to the pilot generator.

The net result of this procedure is closer control of system frequency than could be obtained with only a single generator operating on flat frequency control because the generator or generators with biased control assist the pilot generator during the periods of fluctuations. The rotary switch is set at L-F, "load biased frequency," and tables can be supplied to show the amount of bias required.

Automatic Frequency Control With Automatic Economic Load Control Between Generators

This scheme is adapted to obtain the same flexibility of control as is obtained with the proportionate load distribution scheme described above. As previously mentioned, its recommendation in preference to the proportionate load distribution scheme depends only upon the dissimilarity of the efficiency characteristics of the generators concerned or for

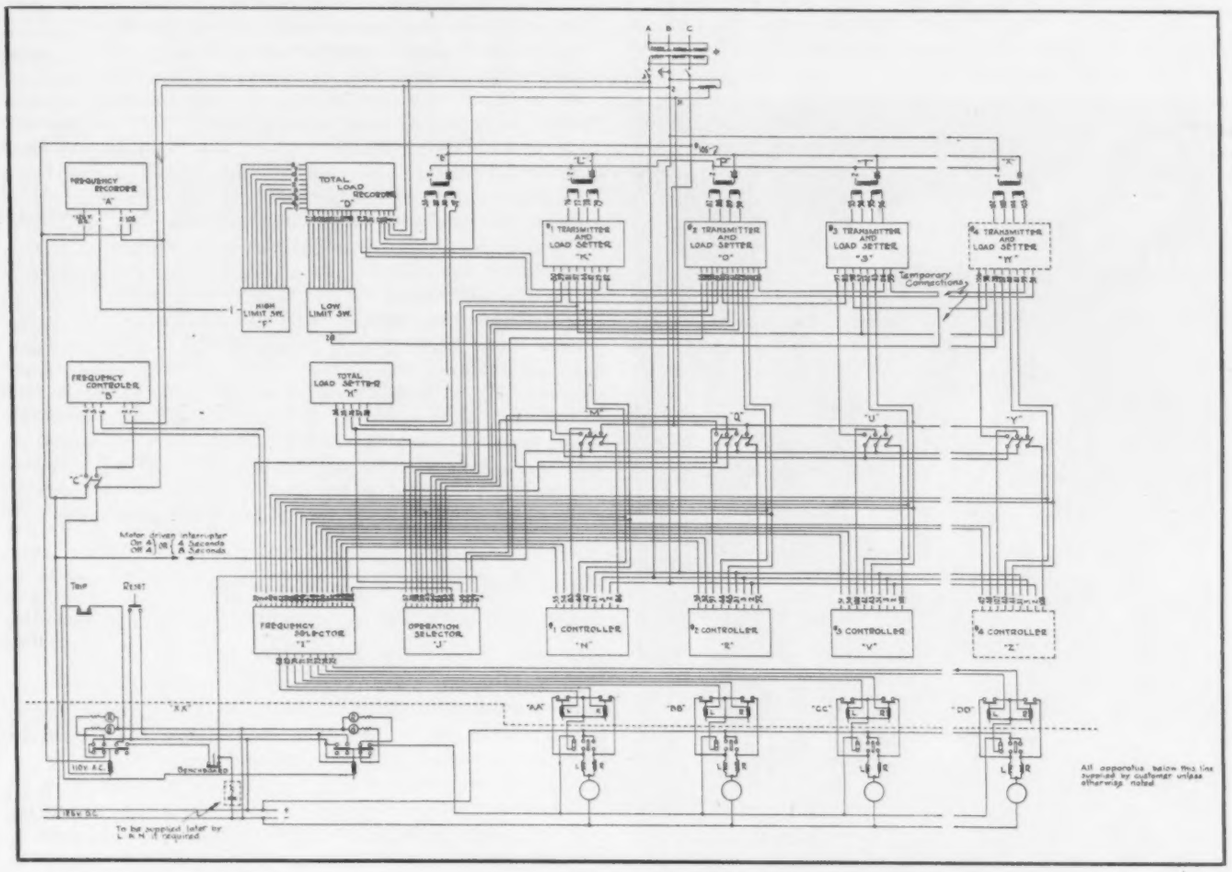


Fig. 7. Wiring diagram of automatic frequency control with automatic economic load distribution between generators as now installed at the Norwood Station of the Carolina Power and Light Company.

With the arrangement capable of giving either flat frequency control with automatic load distribution or with base load control, this added feature of biased load frequency control can be obtained and is available if at a later date it is desired to operate an entire system with automatic frequency control with a number of stations participating in the control at the same time.

Fig. 6 gives the complete detailed wiring of the control equipment for the frequency proportionate load distribution scheme. With reference to this diagram we wish to call attention to the arrangement employed in introducing a potential from the shunt across the current transformer into the circuit, which is proportional to the power component of the current output from an individual generator. The phasing potential transformer shown in the upper portion of the drawing is adjusted for unity power factor and if the particular generator is operating at a power factor less than unity, the potential drop across the shunt is corrected correspondingly. The equipment is therefore independent of power factor.

adaptation in such instances where economies result from the use of certain fixed and predetermined loading schedules. Fig. 7 gives complete wiring diagram of the automatic frequency control with automatic economic load distribution between generators as now installed at the Norwood Station of the Carolina Power and Light Company.

The arrangement of automatic control with automatic economic load distribution incorporates the following features of operation:

1. Frequency control of the entire station, with automatic economic control of load distribution among the various units.

2. Base load control on the entire station without regard to frequency and with automatic economic distribution of load among the generators.

3. Adjustable load control on the entire station independent of frequency and also independent of any automatic economic distribution of load. In other words, base load control with manual adjustment of the ratio of loads carried by the various machines.

4. Biased load-frequency control on one generator with economic distribution of the load among the remaining generators.

5. Operation of station with a combination of certain of the above features; for instance, automatic frequency control on one generator with the remaining generators set manually for any desired ratio of load.

The manner in which these features of control are accomplished is essentially the same as the proportionate load distribution scheme. For the entire group of generators one frequency control setter is utilized which contains an impedance bridge circuit for frequency control. By suitable selector switches the controller of any one unit can be employed with this bridge circuit and again this generator is selected as a pilot for the frequency regulation. Instead of a shunt in the current transformer curcuit of each generator, a Westinghouse graphic watt-meter is utilized on each machine

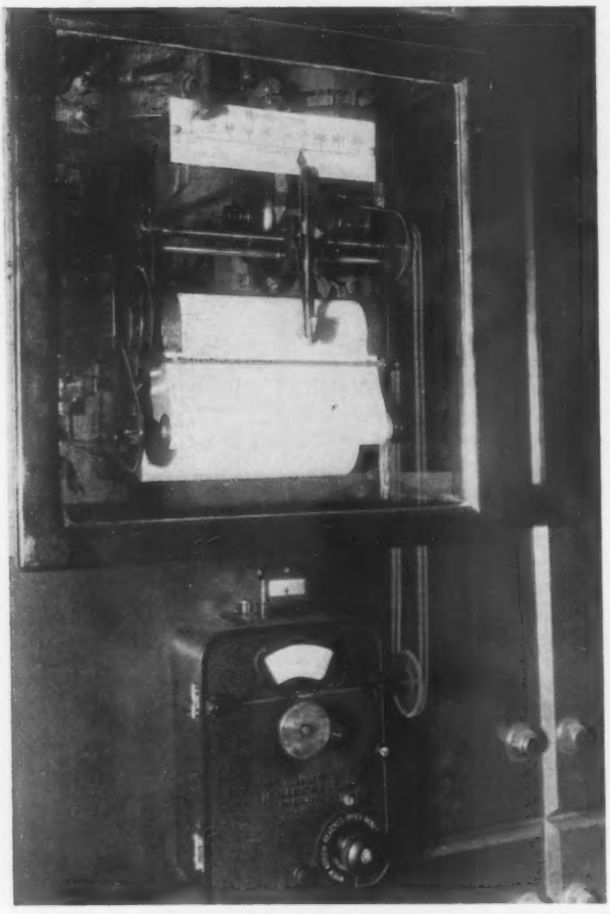


Fig. 8. Mechanical connection of transformers to wattmeter.

to drive a transmitter which contains two slide wires. One slide wire is used for remote indication of the load on the machine and is connected to a total load recorder. The second slide wire of the transmitter is calibrated in accordance with the efficiency characteristics of each individual generator. These calibrated slide wires operate on the principle of a.c. potentiometers. The manner in which the transmitters are connected mechanically to the wattmeter is shown in Fig. 8.

A frequency recorder is utilized both for the record of operation which it furnishes and for the protective feature, which is accomplished by utilizing contacts in the recorder which will open the automatic control circuit if the frequency exceeds certain predetermined high and low limits, and at the same time turns the station over to manual control of the generators. The total load recorder, in addition to providing a record of the station load, has contacts mounted in it which operate in conjunction with high and low "load-limit" switches which enable the operator to hold the total load variation on the station to certain limits. In the event that there is a tendency to exceed these limits, the automatic control is automatically cut out and the station is turned over to manual control. Through special switches the automatic control is so arranged that any adjustment on any generator may be made immediately. Any attempt to change the scheme of control, for instance, from frequency control to base load control, results in the disconnecting of the entire automatic control, which must then be reset. In addition to the above, protection is further provided through low voltage relays which will open the automatic control circuits and place the station on hand control.

It seems unnecessary to describe the operation of this system in detail since practically all of the features correspond with those described under the proportionate load distribution scheme. For load distribution control the potential drops along the calibrated slide wires in the transmitters are opposed and provide the same sort of control as is obtained with the shunts in the proportionate load distribution scheme. For base load control the potentials along the slide wires in the transmitters are opposed to potentials over similar slide wires mounted in the total load setter. Each transmitter is equipped with a switch having two positions, one marked interconnect and the other independent. For adjustable load control on the entire station independent of frequency and also independent of automatic economic load distribution, these switches would be set in the independent position and then by adjusting a separate dial mounted in the same transmitter, the operator may regulate the load on any generator to any particular point that may be required.

Method II.—Synchronous Clock Control—

Description of Automatic Frequency and Load Control Equipment

In order to study the details of this device with the least confusion let us confine our attention for the time being to one station with a plurality of generators equipped to control automatically frequency and load. It should be emphasized here that sufficient generating capacity must be assigned to automatic control to take care of the maximum expected load change in the system during a certain definite period. Load fluctuations in excess of this magnitude over greater periods must be absorbed by base load stations, shifting load "in block," thereby keeping the required load in the automatic station or stations within the normal capacity. The automatic frequency and load control equipment in this station would consist essentially of:

1. A master frequency regulator.
2. A unit load controller for each prime mover.

Combined Operation of Master Regulator—Several Controllers

A complete set-up for one automatically controlled station is shown schematically in Fig. 9 with two unit load controllers for two prime movers. As many unit load controllers as desired for additional machines can be added by merely connecting the additional secondary relays for the governor control motor circuits to auxiliary busses 54 and 55.

When contact 12 in the master regulator is closed as a result of low frequency the "raise" master relay 41 is closed, energizing auxiliary bus 54 to which are connected all the "raise" secondary relays in the governor control motor circuits. When the control equipment is operative, i.e., with the reset relay 43 closed, these secondary "raise" relays will close provided the respective unit load controllers are

in the proper position. The closing of these relays causes the governor-control motors of the prime movers to respond to the correcting impulses, increasing the load on these machines until the unit controllers open the impulse circuit, which occurs after the load has reached the proper value. Similarly when the contact 11 in the master regulator closes as a result of high frequency, the "lower" master relay 40 is closed and auxiliary bus 55 for all the secondary "lower" relays in the governor-control motor circuits is energized, resulting in a decrease in load as indicated by the unit load controllers.

The master regulator detects errors in system frequency, simultaneously sends out correcting impulses, and records the integrated error between system time and pendulum time in the unit load controllers. Suppose for example in a given 60-cycle system the load is suddenly increased by an amount sufficient to drop the frequency 1/10 of a cycle. If the total active generating capacity of the system and the system load-speed characteristics are known, the actual magnitude of the load increase is then known and the automatic station must pick this up in order to restore the frequency to normal. If the automatic station were able to visualize this load change immediately and respond accordingly the frequency would never have dropped. However it takes a certain time for the control mechanism to respond, and the system has been operating slightly below normal during the time it takes to get the load increased on this station by a sufficient amount to give normal frequency again.

Integrated time error can therefore be used as a basis of loading the machines in the automatic station. As the load on the system increases the system tends to run slow; the master regulator causes the integrated error hands on the control boxes to move ahead and impulses are sent to the control motors of proper direction and magnitude to cause the load on the machines to follow the time error hands. It should be borne in mind that after each successive change in load the system is back to 60 cycles, but during this adjustment a slight change in time occurred. Experience has determined that it is practically possible to transfer the total load of a station with an integrated time error of one second on the system.

The unit load controllers are in a sense electrically geared together in such a way that their loads follow correctly the position of the integrated error hands and are unable to depart from this value while under the control of the automatic equipment.

In case the system frequency varies in excessive amount the emergency contacts 19 close and energize the trip relay 42. The reset relay 43 must be closed for the equipment to be operative, since this relay is in series with the impulse circuit of all the unit load controllers. The reset relay is also tripped out by any manual attempt to adjust the load on the machines with the governor control switches 53 and 56. The equipment is made operative again by pulling the reset swith 51 to close the reset relay.

The Master Frequency Regulator

The master regulator, as shown in Fig. 10 and by the schematic arrangements in Figs. 8 and 11, contains an extremely accurate pendulum which is used as a standard of frequency and time. The system frequency is checked with the beat of the pendulum and correcting impulses are sent to the generator prime movers every two seconds. The following description pertains to one of the earlier regulator designs, which on account of its simplicity lends itself more readily to an analysis. Experience has led to several

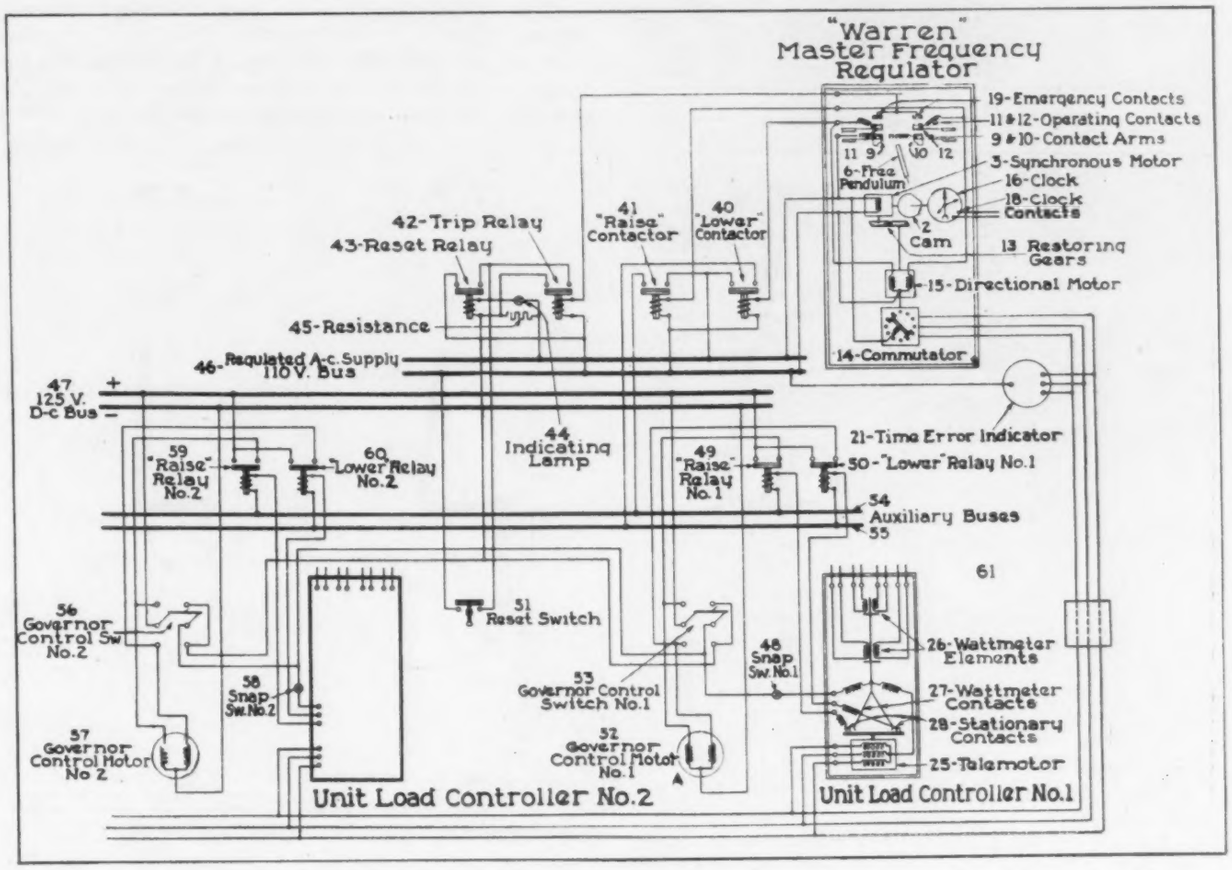


Fig. 9. Schematic wiring diagram for automatic frequency and load control.

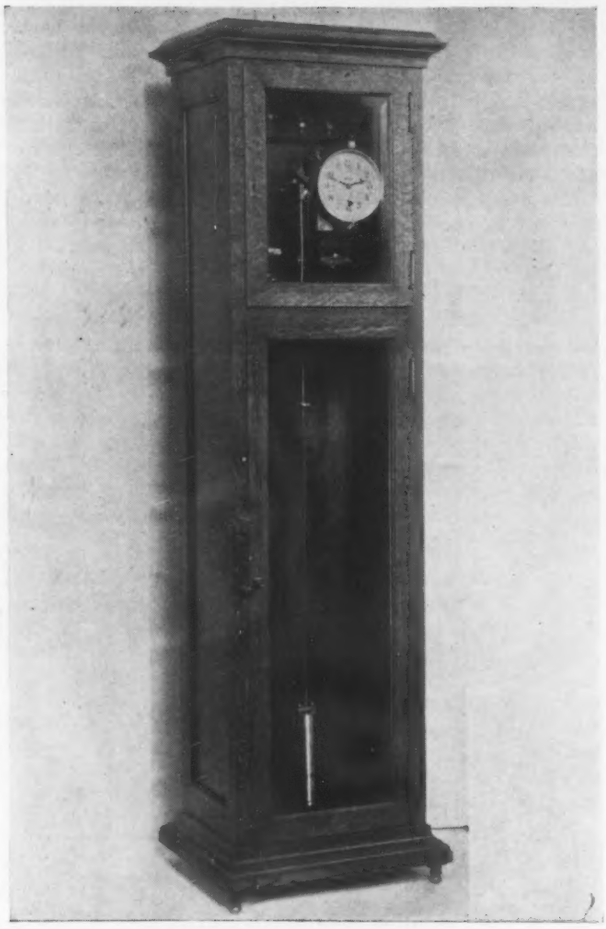


Fig. 10. Master frequency regulator.

refinements of the basic principles but will not be referred to here.

The Pendulum—The pendulum (Fig. 11) in the master regulator is of the proper length to give one complete oscillation in two seconds with the major portion of the weight at the lower extremity. The pendulum rod is made of invar to compensate for practical temperature changes and adjustments are made in the field by adding small calibrated weights to a pan 20 located part way up the pendulum rod. These weights are calibrated in "fractions of a second per day." When reasonably installed and properly calibrated this pendulum will keep time within one second per day. It is advisable to check pendulum time at least once a day with Arlington time by any of the approved methods, using an inexpensive permanently tuned radio signal receiver.

Energizing the Pendulum—Located near the pendulum support is a cam 2 driven by a synchronous motor 3 from the regulated system and geared to make one complete revolution every two seconds if the system frequency is correct. In normal operation when the pendulum has already reached its maximum position to the right and is receding, the flat portion of the cam will be approaching the top in a clockwise direction and will then allow the follower 4 to drop. In doing so, the light steel rod 5 is allowed to press against the pendulum 1, imparting to it a small definite gravitational impulse since the follower is not supported by the cam at this instant.

As explained in the following paragraphs, the cam is brought back into the proper phase relation at every revolution so that the impulse is imparted at the correct pendulum position at every oscillation. These impulses are of the proper magnitude to maintain the correct amplitude of pendulum swing, and the energy obviously is supplied by the motor driving the cam through the process of lifting the light steel rod away from the pendulum after the impulse has been given.

Detecting Errors in System Frequency—The cam also has another important duty to perform. Referring to Fig. 11b it is seen that just before the flat part of the cam arrived

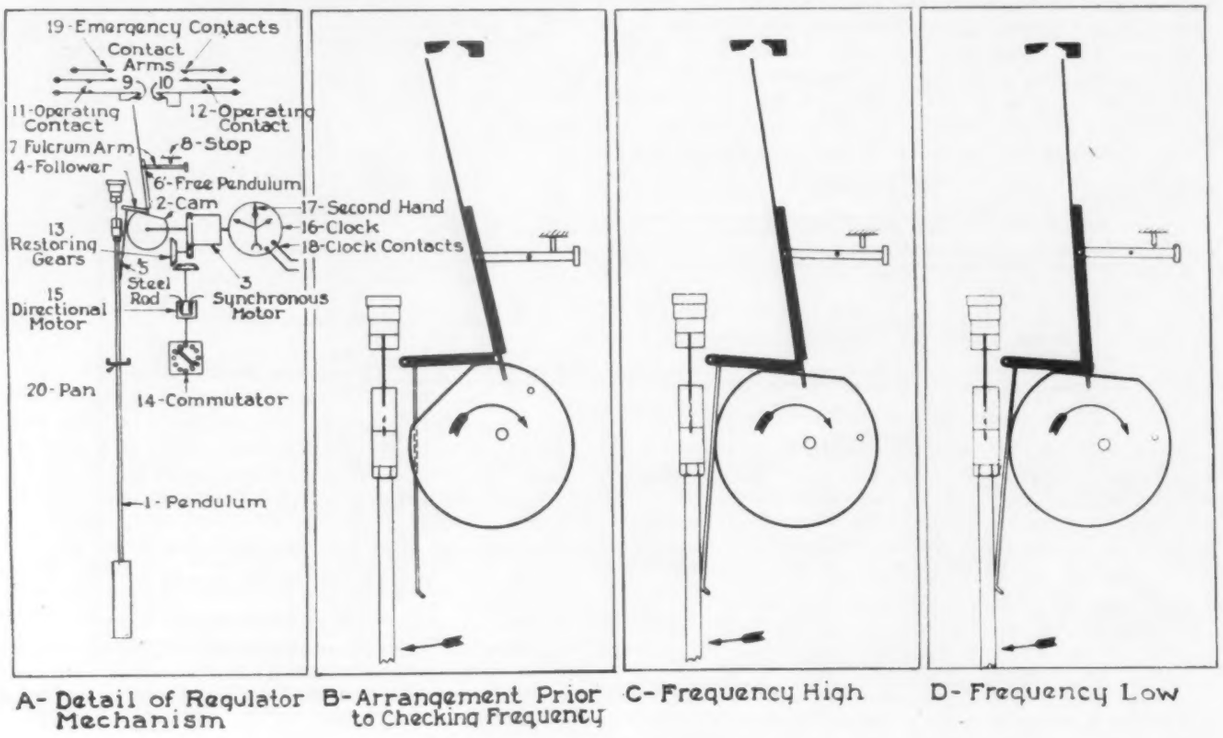


Fig. 11. Detail of regulator mechanism.

at the top, a pin bumped the push rod 6 to the right off the follower 4. The push rod acts then as a free pendulum supported in the middle by the fulcrum arm 7 which on account of the weight of the push rod has swung to a definite position as determined by a stop 8. The push rod is also in such a position that it tends to swing about its fulcrum in a clockwise direction as soon as the follower is lowered by the arrival of the flat portion on the cam. So while the push rod is swinging to the left over the follower the cam has allowed the light steel rod to impart its impulse to the pendulum and then the longest radius of the cam raises the follower to its extreme height, catching the free pendulum or push rod somewhere in its swing.

In normal operation the push rod is caught on the "follower" in such a position that it will be raised in a neutral zone midway between the two contact arms 9 and 10. If the cam is ahead because of high system frequency the push rod will be raised in a position as shown in Fig. 11c and if the cam is behind because of low system frequency the push rod will be raised in a position as shown in Fig. 11d. It should be emphasized that the push rod is always trapped in a position which is off center by an amount proportional to the cam displacement. The push rod is raised by the use of the cam to an extreme upward position, closing the contacts at once, and as the cam advances and the radius decreases the push rod slowly drops to a position where the contacts are opened. On account of the stepped nature of the contact arms then the contacts are closed for a period which is proportional to the amount the push rod was off center because of a corresponding error in cam position. The closing of these contacts will be referred to as the correcting impulses "generated by the master regulator."

It has been pointed out that the correcting impulses are of a duration proportional to the cam deviation, which is equivalent to the integrated time error of the system during the two-second interval, and since the interval is so short,

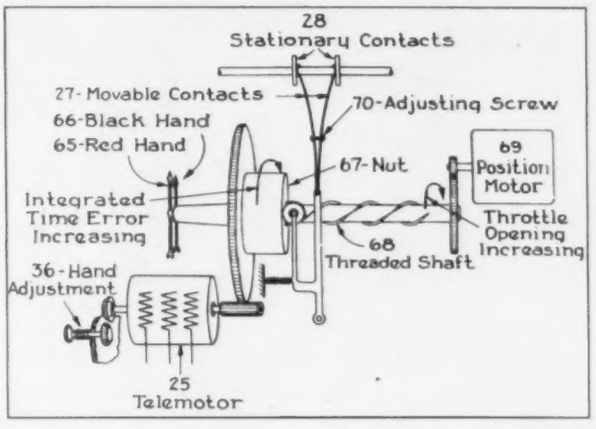


Fig. 12. Unit load controller, position motor type.

the impulses are practically proportional to the instantaneous frequency deviation.

Restoring the Cam—Suppose during any revolution of the cam that it has fallen behind on account of low frequency by an amount sufficient to generate a correcting impulse. Without considering how it is done, for the time being, this impulse goes to the governor-control motors giving them a few turns to open the governors, resulting in an increase in system speed. This same impulse simultaneously causes directional motor 15 to run at a definite speed and through a proper gear ratio to shift the stator of the cam motor, thereby restoring the cam into the correct phase relation with respect to the pendulum. The cam is now starting from scratch again and is ready to check any existing frequency error in the system during the next two-second interval.

Experience has determined just what magnitude of impulse per cam deviation gives the best operating result. Suffice it to say that a generous impulse is sent out when necessary, and the cam is restored by this total impulse while the unit-load controllers decide, as is shown later, whether it is necessary to send all of this impulse to every governor-control motor or not. The master regulator presupposes that the correcting impulse would give the desired results and then with the cam restored into correct phase position and the system frequency back to normal no more impulses will be sent out until another disturbance in frequency occurs.

The restored motion of the cam is important in that it allows energizing impulses for the pendulum to be imparted at the proper time, causes correcting impulses to be sent out which are practically proportional to the instantaneous frequency deviation and prevents correcting impulses being sent out to produce a hunting cycle.

Integration of Time Error—It is evident that restoring the cam with every impulse causes a slight time error to remain in the system. However the magnitude is very small and a record is kept of the actual magnitude and used as a basis for dividing load between the machines. When the cam is being restored by the directional motor 15, a commutator 14 in the master regulator is turned by this directional motor and this commutator transmits impulses to the telemeters in the load controllers. Thus each unit load controller has a hand on it which at any time tells what the integrated time error in the system is, provided no manual adjustments have been made.

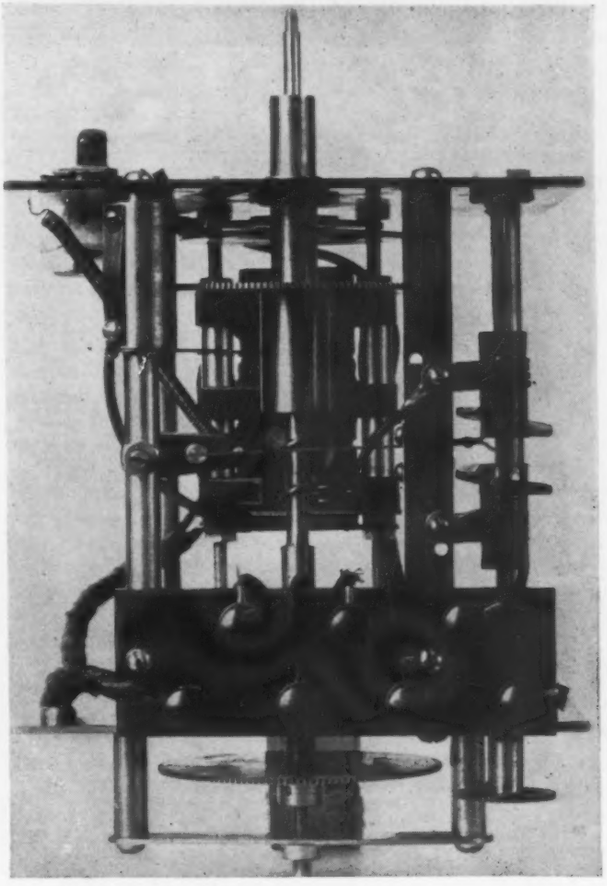


Fig. 13. Unit load controller mechanism, position motor.

Pendulum Time—Pendulum time is indicated on the standard clock dial 16 in the master regulator. The clock is operated directly from the cam shaft by the same motor that indirectly energizes the pendulum. Since the cam is restored into time phase with the pendulum, this clock

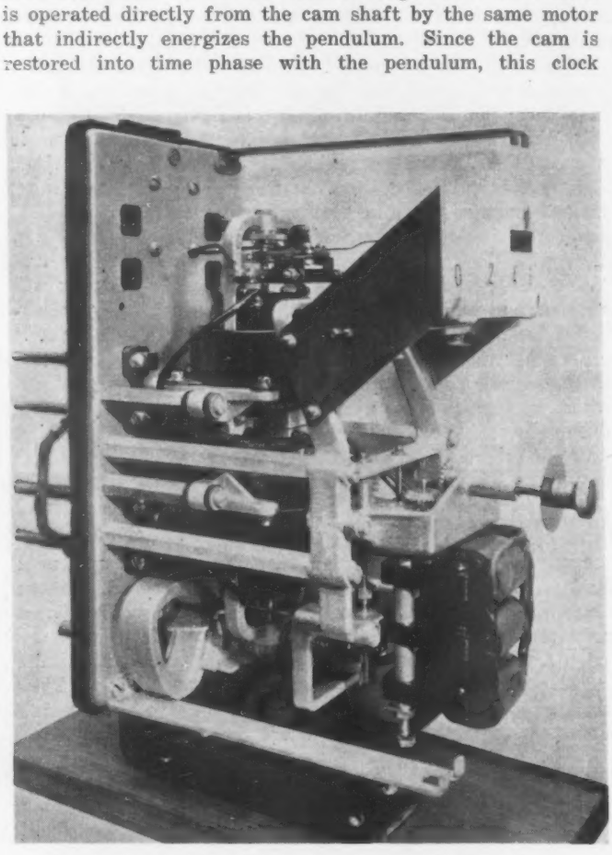


Fig. 14. Wattmeter type unit load controller without cover.

records pendulum time with a possible error of plus or minus 1/400 of a second since the cam position may vary by that amount and not result in a correcting impulse.

The clock is equipped with a second-hand which makes one complete revolution per 30 pendulum oscillations and, practically speaking, per minute. This clock is also equipped with contacts which close once per minute and may be used as one means of checking pendulum time with Arlington time.

Sensitivity of the Impulse Generator and Emergency Signals—Tests show that deviations of the cam position of plus or minus ½ degree will cause the first order of impulse to be given out. This means that the average frequency error for the last two seconds was 0.075 cycle on a 60-cycle system and that the accumulated time error during that period was 1/400 second. If the frequency error is as much as ¾ of a cycle on a 60-cycle system the emergency contacts 19 are closed and the automatic equipment tripped free from the machines. Further, any attempt to change the load manually through the governor-control motors trips the automatic equipment free. An indication is then given to the operator that certain conditions have arisen on the system which the automatic equipment is not expected to take care of.

These emergency limits which at first appear to be rather narrow are quite ample, since on a system reasonably saturated with automatic control equipment ordinary severe load shocks seldom cause frequency errors greater than 0.2 cycle.

The Unit Load Controller

Each prime mover assigned to automatic frequency and load control in a station is equipped with a unit load controller. These controllers act as filters for the impulses which come from the master regulator on their way to the governor-control motors in such a manner that the loads on the geenrators can be divided in a predetermined ratio. At present there are two types of unit controllers.

(*a*) Unit load controller, position-motor type.
(*b*) Unit load controller, wattmeter type.

Unit Load Controller, Position-Motor Type—This type of controller shown schematically in Fig. 12 checks the load on each prime mover in terms of operating cylinder position on steam turbines and in terms of gate opening on a waterwheel. A Selsyn generator located at the prime mover energizes a corresponding Selsyn motor 69 in the unit controller, which is located in the operating room thereby giving a positive indication of either operating cylinder position or gate opening. Fig. 13 shows the mechanism of this type of controller. It is arranged to be attached to a frame similar to that shown in Fig. 14 and is thus suitable for switchboard mounting.

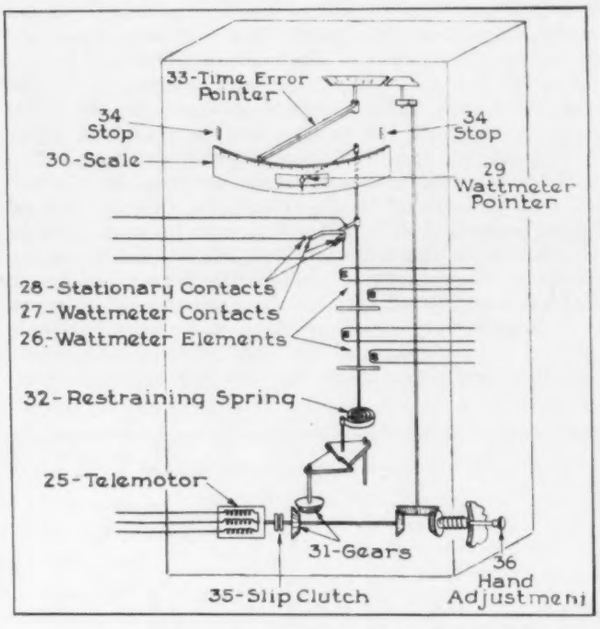


Fig. 15. Schematic detail diagram of unit load controller.

While the flow-travel curve of a steam turbine is not a straight line and hence load is not strictly proportional to valve opening, this discrepancy is not of sufficient magnitude to prevent the controllers dividing the load satisfactorily between machines.

Load Indicator—Referring to Fig. 12 it is seen that the load indication is reflected into the controller through the Selsyn motor 69. As the throttle opens from no load to full load the threaded shaft 68 turns approximately 300 degrees and a red hand 65 on the dial in front indicates the throttle position.

Integrated Error Hand—The telemotor 25, which is energized by the commutator in the master regulator, turns in response to integrated error in the system and in so doing turns the nut 67. The position of this nut is indicated by the position of the black hand 66 on the dial and the gear ratios are so chosen that the black hand covers approximately 300 degrees of arc for one second integrated time error.

The movable contacts 27 will be centrally located when the two hands are coincident, i.e., the load (throttle posi-

tion) corresponds to the integrated time error. As the system slows down the telemotor revolves and turns the nut 67. This moves the contacts to one side allowing only impulses to go through, which will increase the load on the machine; and as the throttle is opened, the Selsyn motor 69 turns the threaded shaft 68 in such a direction that the contacts become central once more and the two hands on the dial coincide. The function of this unit controller is then to allow impulses to go through to the governor-control motors so that the red throttle-position hand follows faithfully the position of the black integrated time-error hand.

Unit Load Controller, Wattmeter Type

This type of controller, as shown in Figs. 14, 15 and 16, checks the load on each prime mover directly in terms of generator watts. It is designed for switchboard mounting and in addition to giving a direct check on the machine output, dispenses with the electrical connections between the turbine room and operating room to operate the Selsyns. This device, as shown in Fig. 16, is suitable for mounting on the switchboard panel.

Wattmeter Element—The unit load controller, as shown in Figs. 14, 15 and 16, consists primarily of a standard

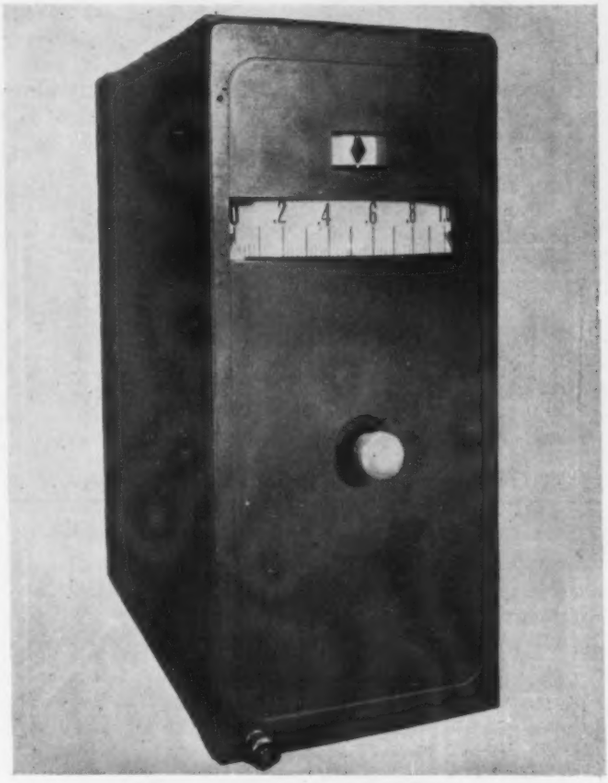


Fig. 16. Wattmeter type unit load controller.

single-phase or polyphase graphic wattmeter 26 with the curve-drawing elements removed. It is designed to give high torque without imposing too much additional burden on the instrument transformers of the generators which now supply the meters and instruments on the generator panel.

The shaft has mounted on it two insulated contacts 27 at the same potential, which rotate with the shaft over a limited arc between the two stationary contacts 28. A pointer 29 which shows through a small opening in the scale plate 30 indicates zero when the wattmeter contacts are central with respect to the stationary contacts and both circuits will then be closed.

Integrated Error Hand—The commutator in the master regulator as it turns energizes successive coils of the telemotor 25 in each unit load controller, resulting in rotation of the telemotor shaft. As the system slows down the telemotor revolves and through the sector gears increases the tension on the wattmeter spring. This means that it will require more load on the generator to produce a corresponding wattmeter torque to neutralize this increased tension of the spring and bring the small pointer 29 back to zero, in which position the contacts are central and the machine is at the required load.

When the spring tension requires no wattmeter torque to balance it the integrated time-error hand 33 will be at zero. As the tension on the spring is increased, this integrated time-error hand is simultaneously moved across a scale until the spring has a tension requiring full-load torque to balance it when the error hand is at full scale. This error hand then indicates the load on the machine if the small pointer 29 is at zero.

Division of Load Between Machines—Referring to Figs. 9 and 11, the master regulator's contacts 12 will be closed intermittently on account of a slow system frequency. The closing of this contact closes the corresponding contactor 41, which is capable of handling current for all the governor motors. In the meantime the master regulator was turning the commutator and increasing the tension of the wattmeter restraining springs in all the watt unit controllers and moving the nut 67 in the Selsyn unit controllers through the medium of the telemotors. The unit control contacts are now in such a position that only impulses which will increase load on the respective generators can go through to the governor-control motors. If the governor mechanism of one unit is more delicate or faster than others (see Fig. 17A machine 1) the impulses will be allowed to go through until such time as the watts output or throttle position corresponds to the position of the integrated time-error hand and then the circuit is opened. In the meantime, the unit controllers of the more sluggish machines allowed the impulses to go through until their loads were of the proper amount.

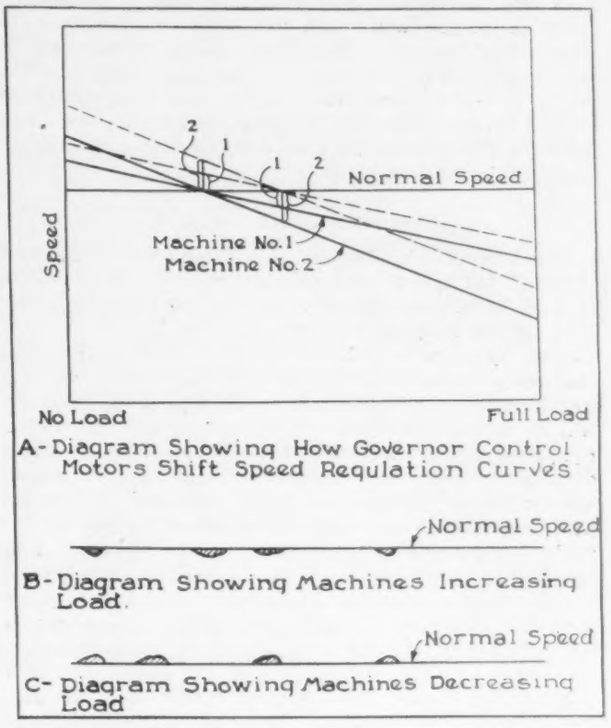


Fig. 17. Diagram showing how governor control motors shift speed regulation curves.

The unit controllers thus dictate to their respective machines and proportion the impulses of the master regulator so that load is eventually divided proportionally to the ratings, independently of the speed-governor characteristics and as a direct function of the system time error.

Limiting Load on a Generator—Adjustable stops are arranged in the unit load controller wich restrict the travel of the integrated time error hand. If 9/10 load is the maximum desired on a generator, the stop 34 would be set so that when the error hand reached the stop it would require only 9/10 watt to balance it. A slipping clutch arrangement 35 allows the telemotor to continue to respond to the clock, but this unit controller will not allow any additional increasing impulses to go on to the control motor. This means, of course, that the regulation requirements are taken care of by the remaining machines. The minimum load stop accomplishes similar results. A similar stop arrangement is used on the Selsyn type whereby the rotation of the nut 67 is limited.

Rate of Load Transfer—At present the gear ratios are chosen so that an integrated time error of 1.0 second will move the error hand in the unit load controllers to full scale, demanding full load on the machines. This means that if load is increasing on a 60-cycle system at such a rate as to keep the average frequency 1/10 of a cycle low, the automatic equipment will function to increase the load on that station at a rate of approximately 1/3 capacity every three minutes.

Readjusting the Load on the Generators—If at any time the operator would like to increase the load on a generator, he may do so through the automatic equipment. A thumbscrew 36 is arranged on the unit control box to allow manual adjustment of the integrated error hand. If this hand is moved over to a new position requiring more load, the unit control box and the generator function as if this increased error were true and had come from the master regulator. In a practical set-up there is sufficient continual change of load in the system to cause the master regulator to be sending out intermittent raise and lower impulses. The raise impulses will be passed on only to the control motor of the generator whose unit controller error hand has been shifted manually. The forced loading of this machine will be reflected into the system frequency, causing the other machines to drop some load. Finally when this adjustment of load has taken place the one machine will have extra load equal to the amount the time error indicator was moved manually in the first place (see Fig. 18).

Discussion of Applications

One Automatically Controlled Station in an Interconnected Area—If the system load suddenly increases by a definite amount, then irrespective of where the load was added (this neglects line loss) all machines immediately increase their outputs by an amount inversely proportional to their mechanical governor regulations and the system will run at a correspondingly lower frequency. This drop in frequency will be detected by the automatic station and the control equipment will increase this station's output at a certain definite rate until the frequency is brought back to normal with no manual attention, all other machines on the system will be delivering their original output on account of the mechanical-governor characteristics and the total load change has been absorbed by the automatic station as a result of a temporary drop in frequency and at the expense of a slight lag in system time. During this cycle of events the system was running at a slightly reduced frequency for a short interval, resulting in a loss in system time of a fraction of a second. This error was recorded in the unit control boxes of the generators in the automatic station and used as a basis of controlling their load division. This small error in time will remain constant so long as the load on the system remains unchanged. It is gained back again (Fig. 17) only by unloading this station because of a decreased load on the system, causing a slightly high frequency for an interval long enough for the automatic station to drop this increment of load.

Such an arrangement would without doubt be impractical in the average interconnected area since certain of the lines would become over-loaded as a result of all changes in load finally being taken care of from one point. Partly to overcome this difficulty, supplementary control features could be added and these will be discussed later.

One Automatically Controlled Station and Supplementary "Total Watt" Control on Other Stations—An analysis will show that each non-automatic station finally tends to hold constant load on acount of its speed-governor characteristics. Hence there is nothing for a total watt-control device to do.

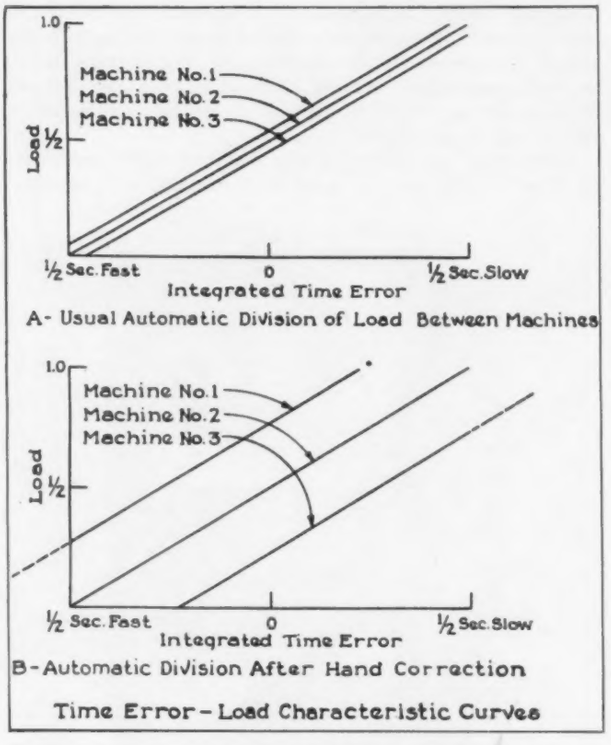


Fig. 18. Curves showing relationship between time error and load.

One Automatically Controlled Station and Supplementary "Tie-line" Watt Control on Other Stations—It is important to make the supplementary control sluggish compared with the automatic frequency control in order that it may not cause too much disturbance during the readjustment. In either of the two previously mentioned cases suppose that a tie-line load coming into a certain non-automatic station has become excessive after the automatic equipment has functioned. The tie-line watt-control equipment then will slowly cause the non-automatic frequency station to take on load, reducing the tie-line load. As this station slowly increases its output the change in load will reflect into the system and slightly change the frequency. The automatic frequency station will then back off the corresponding amount and finally the system will be steady, with sufficient extra load on the one station to keep the tie-line load within certain limits and the additional load change taken by the automatic station.

Several stations in a system could be operated on this basis by choosing a sufficiently important tie-line to regulate

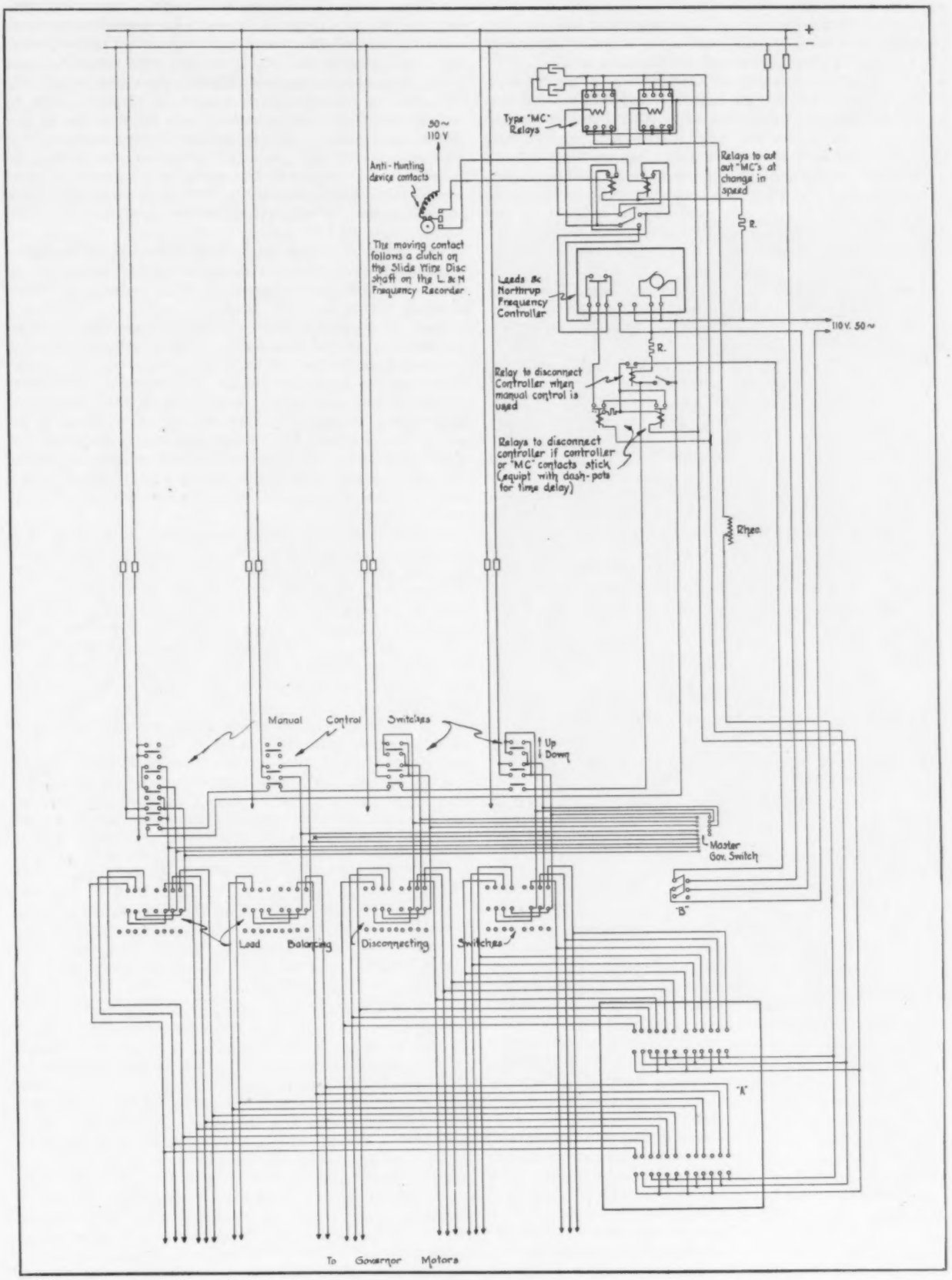


Fig. 19. Frequency controller wiring.

and letting the initial and final adjusting be done on the automatic frequency controller station. Such an arrangement causes an intermittent change in load from one point to another in the process of adjusting itself and for this reason would seem objectionable as a complete solution to controlling the frequency of an interconnected area.

Several Automatically Controlled Stations in an Interconnected Area—As usual, all machines and stations will first share load fluctuations as dictated by their prime-mover governors and the system will suffer a corresponding frequency change. Now each station assigned to automatic frequency control will have a master regulator and unit load controllers for each generator. Then each automatic station will respond to the frequency change and contribute its share to correct this frequency by an amount inversely proportional to the time-error load characteristic of the equipment in the respective stations.

This type of control would be practically ideal if the load change were uniformly distributed about the system. However if all the load change is to be fed to one point, certain tie-lines may become overloaded.

Such a condition may be relieved somewhat in some instances by making certain stations more responsive than others. For instance if all stations were ordinarily able to transfer their total load while the system was changing 1 second, it might be advantageous to alter the control equipment in one or two stations to change load in ½ or ⅓ second time error. This would make these stations more sensitive to frequency change just as a narrow governor is more sensitive to speed changes. This alteration merely means changing gear ratio in the master regulator and unit load controllers of the station which is required to do more regulating.

The question of operating several stations in multiple from multiple standards also requires consideration. Let us assume that one pendulum in the system runs 1 second fast per day and that all other pendulums are correct. Then this station will tend to absorb load at the rate of "station capacity" per day if it is operating on a 1-second time error basis of loading. This does not represent a fast transfer of load; nor is it the purpose of the automatic frequency control equipment to dispense with the load dispatcher. The dispatcher therefore watches division of load between stations as he always has done and the operators change the setting of the unit load controllers accordingly.

These forced changes of station load will be reflected through the system and absorbed automatically by all stations in the system assigned to automatic control. The ultimate success of automatically controlling an interconnected area will be approximately proportional to the degree of saturation with automatic equipment.

Present Installations

Inquiry of installations of automatic control in hydro plants have shown that there is only one company in this district having automatic equipment in service. The frequency controller was first tried out in one of that company's major hydro-electric plants in the latter part of December, 1928, with no auxiliary relays or protection other than two auxiliary relays operating the speed setting control motors of No. 4 unit. At that time the controller was mounted at the back of the switchboard out of sight of the operator who would have to leave his meters and go behind the board to make any adjustments to the controller or even to take it out of service in an emergency.

This installation gave trouble in several ways. The relays would stick closed and run the speed either up or down and would make a very undesirable long whisker on the frequency chart before the operator could get the controller out of service. Another trouble was experienced in manually supervising the load or balancing the governors of No. 4 unit when the controller was in service in that the supervision had to be synchronized with the controller, otherwise a fuse on the motor circuit would be blown if the controller attempted to "boost" and the operator to "buck" at the same time. The last trouble was due to the controller and governors not being adjusted for working together, the result of which was a continual swinging or hunting of the system speed, although the average speed or synchronous clock time was fair.

Corrective measures were started in January, 1929, by moving the frequency controller to the front of the switchboard and mounting it beside the graphic frequency recorder, as shown by Fig. 22. In such a position it was readily accessible for 50-cycle positive or negative adjustment for gaining or losing time and conveniently near the recorder so that notes of changes of adjustment could be observed and written on the chart.

The auxiliary relays were replaced with a more rugged type and after the contacts were shunted with condensers no further trouble was experienced with contacts or relays sticking.

Four six-blade single-throw knife switches were mounted on the back of the frequency controller subpanel and are operated from the front of the board by pull rods with knobs. When any one knob is pulled out the controller is connected directly to the speed control motors of both governors of the respective generator. The switches are indicated as "A" on the schematic print (Fig. 19) and are on the motor side of the knife switches which are used to cut one governor motor out when the operator desires to pick up load on one wheel only, as when correcting a load unbalance between the two turbines of one unit.

A three-blade single-throw knife switch is mounted in a similar manner, being controlled by a rod extending through the same subpanel located just above the others. This switch marked "B" is the master switch for the controller and opens both the a.c. and d.c. feeds. When the controller is to be put in service the operator closes this switch first which starts the controller and auxiliary relays. If the operation is normal he then closes in switch "A" which connects the contacts of the "up" and "down" auxiliary MC relays to the unit to be controlled.

With this amount of equipment installed the frequency controller was used intermittently for about three months. This was over the "run-off season" and consequently little regulation was done at this plant. However, the occasional regulation up to full load indicated that the controller was an "averager" or in other words an automatic correction for the necessary drooping characteristic of the governors. It was soon apparent that the governors would have to be adjusted for the best combination to work with the controller. Such an adjustment was difficult.

In the first place the frequency controller has a time lag of about 2 seconds. This time lag often aggravated a speed swing by giving a big boosting impulse to the governors 2 seconds late or after they had almost recovered, which of course caused them to overtravel.

In the second place the impulses to the governors were too great if the setting lever cam of the controller was set up so that the controller would operate on the slightest deviation from 50 cycles and the uncontrolled band was too wide for off-peak regulation when the setting lever cam bar was dropped down so that the frequency would have to deviate, say one-tenth cycle from 50 cycles, before the controller operated. (The wandering effect caused by the controller being adjusted to start to operate on a one-twentieth of a cycle deviation is illustrated for an off-peak regulation in Fig. 20A. Such an adjustment causes the speed to hang high or low according to whether the load is coming on or being dropped and at such times a second or two can be gained or lost in 15 minutes.)

In the third place, the speed swings over a peak load are so very much greater than for off peak that some means must

be provided for giving the governors greater impulses during the peaks. It is true that the controller gave gradient impulses, but the gradient would not fit. In other words the motor speeds and gear ratios of the governors were all different, which necessitated some sort of adjustable compensation between them and the still different controller.

It was decided right off that at that time it would be impractical to try to have the controller operate on more than one unit at any one time and since there were three 17,500-kva. generators and one 28,000-kva. unit, the controller would be adjusted to control the 28,000-kva. unit (No. 4). Accordingly the drooping characteristic of the No. 4 unit was set very high which caused the governors to act as if they were on block control, but this was necessary to prevent the unit and controller from hunting because the slightest impulse from the controller was still too coarse for the governors and it was desired to keep the wandering band as narrow as possible. The drooping characteristics of the other three units were then set as low as possible, but long before the point was reached where there was an interchanging of load between governors as a result of zero droop, a point was reached where any further flattening of the droop curve increased the average speed swings. (Just why this occurred was not understood for a time but was later found to be due to the compensating dashpots which were worn and by-passed oil too frequently, which allowed the governors to pick up load too fast and consequently were not dead beat.) However, the governors were left at this best setting for the time and for the next three months the controller and governors regulated with fair results while relay protection and other refinements were introduced into the circuits.

The first protection relays installed were for taking the controller out of service in case a relay stuck closed or the controller itself stopped in such a position as to run the governor motors continuously. As it was thought undesirable to consider any device which would operate to take the controller out of service when an abnormal speed swing occurred, because such swings occur more often than relays stick, two time relays set to operate at 3 seconds were used. (The maximum controller impulse is less than 2 seconds.) The relays were operated by potential, one from the "up" contacts and one from the "down" contacts of the auxiliary MC relays and were connected to open the master feed to the controller if either MC relay should stay closed for more than 3 seconds. In other words if the control stuck and put "boost" to the governors for more than 3 seconds the controller was taken out of service.

This protection will be changed in the near future by having each time delay relay open the coil circuit of its respective MC relay. This operation will be better for the reason that if the control stuck and put "boost" to the governors for more than 3 seconds the "up" circuit would be opened but the "down" circuit would still operate to correct the speed error. The old scheme, however, has worked successfully the few times it has been needed.

The second protection relay installed was for automatically opening the d.c. feed to the controller if any manually operated governor control switch were moved from neutral position. This protection insures full manual supervision without the possibility of blowing fuses on the governor motor circuits. One set of extra contacts was mounted on each of the governor motor manual control switches and these contacts were connected in series with an a.c. relay in such manner that a closed circuit existed through the contacts and relay to an a.c. supply as long as the manual controls were in neutral. The instant the manual controls were moved the relay would drop open, the contacts of which would open the positive leg of the d.c. feed to the controller. This scheme has worked successfully for several months with no blown fuses. The contacts of all protective relays are paralleled by knife switches which can be closed in event of relay trouble or when servicing the contacts.

During the latter part of October and the first of November, load conditions became such that the system swings were more severe than before. The plant did not show up very well in handling the swings so a study was made for improving the operation of the governors. The conclusion was reached and was confirmed by experiment that the ideal adjustment of the governors and frequency controller was as follows:

The governors must be in as good mechanical condition as possible. Particularly must the fly-ball links and all connec-

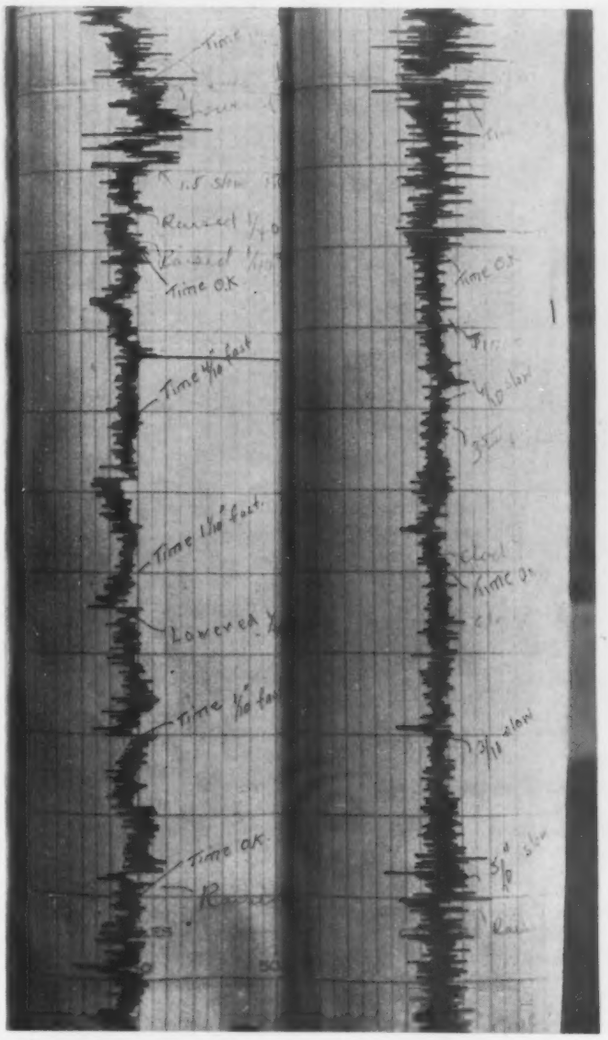


Fig. 20. (Left) Speed curve with cam bar lowered to prevent over-regulation. Anti-hunting device out of service. (Right) Speed curve with cam bar raised to allow controller to go into action on very slight deviation from normal speed and anti-hunting device in service to cut out controller as soon as speed starts to return to normal.

tions to the relay valves be free of loose motion, otherwise the governors will not respond to slight speed changes, the result of which is a "dead band" on the chart inside of which there is no governor action. The effect is similar to that experienced when the relay valves have too much lap for the sensitivity of the fly-ball.

The compensating dashpot mechanism must be in perfect mechanical adjustment to make the governors dead beat. The

cil used in the dashpots should have a constant viscosity over the normal change in room temperature. This is very important. The adjustment or timing of the dashpots is not so easy and must be largely a cut and try method starting from the average adjustment recommended by the governor manufacturers.

Also, system flywheel effect due to the intertia of the rotating apparatus shows up as a lagging of the system speed to the corrective action of the governor and is troublesome for two reasons: First, it is a varying factor due to there being more or less rotative apparatus connected to the system according to the load, thereby making it necessary to adjust the governors for an average load condition. Second, the

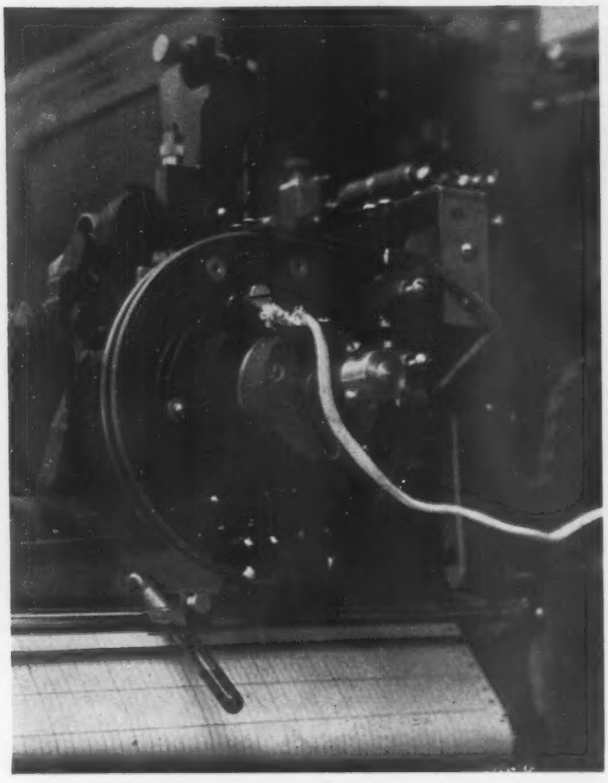


Fig. 21. Frequency controller and recorder as now installed, Big Creek No. 1 hydro plant, Southern California Edison Company.

effect of system rotating inertia on the governors is that the system, possessing a tremendous momentum, can give up a considerable amount of energy by slowing down a slight amount, which occurs before governor fly-balls detect the change in speed. Then after the governor has initiated an increased gate opening, it is necessary not only to pick up the increased load but to supply additional energy to the system in order to accelerate it to normal speed. The time or rate of acceleration depends on the inertia of the system and the additional power or accelerating force applied. It is important that the accelerating force be reduced to zero by the time the speed is back to normal frequency, otherwise an overtravel and resulant hunting of speed will occur. The governor manufacturers have installed on other governors two factors to prevent such hunting. One gives the governor its "drooping speed characteristic" by limiting the amount of load the governor will pick up per unit drop in speed and is accomplished by having a change in gate opening through a mechanical linkage neutralize the fly-ball action by restoring the relay valve to neutral position. This action of the restoring mechanism will taper off any movement of the gates to a gradual stop and will also prevent the governor from going "wide open" or "full closed" for a tiny change in speed, which it would do if this compensation were not provided. The other factor is a compensating dashpot arrangement which times the governor action and limits the rate of picking up or dropping off of load and is accomplished by having a change in gate opening, through a mechanical linkage and dashpot, tend to return the relay valve to neutral position so that the speed of gate opening is limited by the dashpot setting. Of course the above two compensations operate together to give a rather complex action, the result of which is that, when a change in speed occurs, the governors start opening the gates at a rate depending both on the dash pot setting and the drop in speed. As soon as the drop in speed is arrested the gates stop opening, then, as the system speed accelerates to normal, the gates are gradually closed at a tapering off rate, finally coming to rest just as the system speed is normal. This ideal action of the governors is becoming more difficult to reach, not because the governors are not in as good mechanical condition as before, but because demands are being made which are nearing their limit of sensitivity. When it is considered that an attempt is being made to confine the normal operating band to about one-quarter cycle, which is maintaining the speed within one-half of one per cent and that the average governor head moves only 0.015 to 0.035 in. for such a band, it is readily seen that the mechanical adjustment is becoming more difficult. It has been found necessary to set the drooping characteristic very flat on the governors in order to give them increased capacity for picking up load with slight speed change; then to limit the rate of governor action by increased dashpot action to prevent overtravel. (This setting has no effect on governor action during system disturbances as bypass valves under spring tension automatically open under extreme flyball action.) This setting is not quite ideal, but when adjusted for the average load it is the best yet secured. For light loads one or more units are put "on bottom" to prevent overtraveling due to the regulating capacity being too great.

With all the governors adjusted as outlined above, the controller was set to operate on only one unit (two governors) at a time. The controller was adjusted to start giving impulses the instant the frequency deviated from normal. A variable rheostat was then put in the common lead to the governor motors under control. This provided the adjustable compensation between the controller and governors to make them operate successfully together. It also makes a convenient adjustment for securing the proper impulse for different load conditions. For instance, during peak loads the swings are considerable and consequently the controller should have more effect on the governor than during the off peak where the same impulse given for the same speed change would cause an overtravel and consequent hunting.

It was soon apparent, however, that the rheostat was not sufficient adjustment to make the controller and governor operate successfully together. In the first place, the controller continually gave impulses from the time the frequency deviated from normal until it returned. This meant that the governors would receive impulses until they arrested the swing, after which they should be left alone in order that they might cut down the gate openings as the system speed accelerated to normal to prevent overtraveling, but instead the controller continued to give impulses until the frequency passed through normal, which caused the governor speed setting to be too high, so of course the speed overtraveled and the process had to be repeated in the opposite direction. This set up a hunting of load condition between the unit being controlled and the free units. By cutting in enough resistance in the motor circuit, this could be stopped, but the effectiveness of the controller for the picking up of load was

also impaired. It looked as if the gradient impulses of the controller were not spread over a sufficiently wide band. The controller was again adjusted, this time to start giving impulses when the speed deviated a little over one-twentieth cycle from normal. This adjustment did fairly well for peak loads, but for off peak it allowed the speed to drift high or low within that one-tenth cycle band according to whether load was being picked up or dropped off. An example of this drifting is shown in Fig. 20A. This was bad for telechron time.

Accordingly an anti-hunting device, as shown on Fig. 21, was designed and incorporated in the controller circuit. The device depends on a frequency recorder for its operation and consists of a friction clutch carrying two constants mounted on the slide wire shaft of the recorder. One contact will close and hold against a stationary contact when the drum moves in one direction and against the other stationary contact when the drum moves in the opposite direction. These contacts control two respective relays which are in the coil circuits of the MC "up" and "down" relays. The operation is as follows: As long as the frequency recorder pen is moving to the right (speed high) the "down" contact is closed and the down relay can be operated by the controller at any time, but the instant the pen reverses and starts to the left the "down" relay is cut out and the "up" cut in ready to operate. It is thus seen that the controller will "buck" only as long as the speed continues to move high but as soon as the speed starts to recover the controller cuts out and lets the governors, which are equipped with dead beat dashpots, finish the recovery without overtraveling. With the anti-hunting device in service, the controller can be set to start giving impulses upon the slightest deviation from normal speed. The rheostat is used for varying the impulses to suit the load conditions and the type of governor being controlled. The result of all of this is the good average time chart shown for off-peak regulation in Fig. 20B. Fig. 20A and Fig. 20B were taken on identical load conditions one day apart and over the same time.

The general plant regulation is as follows: The automatic controller is set to operate on No. 4 unit. Then as many other units are set free as load conditions warrant. As load comes on, all the free units and the No. 4 unit pick up load by normal governor action. If the load stays on, the controller will keep on notching the speed setting of No. 4 unit up, thus neutralizing the drooping characteristic of the governors and causing it gradually to take over the load which had been picked up by the other units. The free units due to the restoring mechanisms have to return to their original load settings when the speed is restored to normal by the controller, so that when it is all over the No. 4 unit has taken all the increased load and all the units are at their normal setting for another speed swing. When the load on No. 4 unit is too great or too small for efficient operation, the operator redistributes the load manually between the units. The converse holds for the dropping of load.

With the present set-up the average time maintained by the controller is good. In addition an arrangement for automatically maintaining constant time is being perfected, the rate of gaining or losing of system time being proportional to the deviation from true time and thus zero when correct.

Discussion

The present methods of automatic frequency control application are in the course of evolution. This is shown when the automatic control is connected on the synchronizing motors of the governors. This happens to be the easiest place to connect such a device on present units where the governors are installed and in operation. It can be readily seen that, with this connection, the action is to have the automatic device tell the synchronizing motor to pick up load, which in turn transmits the message to the pilot valve. Since the oil pressure actuator system is the most reliable and simple speed reduction system, the operation of the pilot valve may be termed the action of the operation of the gate or needle opening. Therefore, in due course of events it will be entirely possible that the automatic frequency controller will act directly on the gate opening through the pilot valve. The application would be very simple in that the pilot valve would have a normal position with electromagnetic control for functioning in either direction. At this step of the evolution, it will be necessary to depend upon the governor fly balls to take care of large swings of load. In Western practice these large swings in load generally occur when heavily loaded circuits

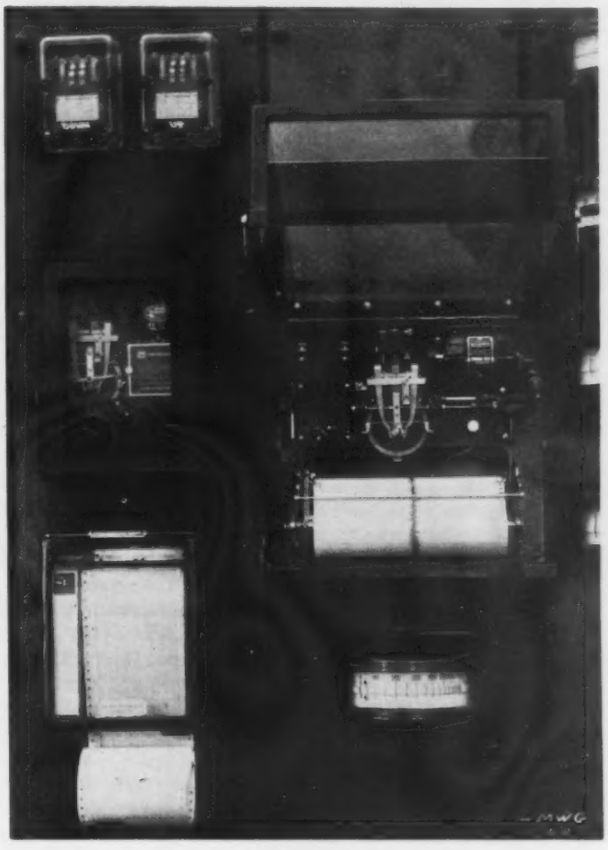


Fig. 22. Frequency controller and recorder as now installed, Big Creek No. 1 hydro plant, Southern California Edison Company.

are dropped or when a loaded machine is dropped off the system either by accident or trouble. The only reason why the fly ball action is necessary is the fact that present automatic frequency control systems operate with periodic impulses. This is purposely done so as not to cause hunting. However, should a large change in load occur, it becomes necessary to have a continuous impulse to correct the speed error. This may be done under the above circumstances by having the present governor fly balls take care of large swings. On the other hand, a second contact on the automatic frequency controller, established so as to occur when the frequency was in error to a large amount, would give the necessary continuous impulse to the pilot valve.

It can now be seen that with this last improvement there is no further need for the fly ball arrangement on the mechanical governor. There is a good deal of objection to this electric control because the wire might become open circuited or the supply might fail. Of course this is true; however, this would only become serious at the time this machine was

accidentally disconnected from the system. Therefore the possibility of these two conditions happening simultaneously is very remote. On the other hand we are all too prone to judge or to compare a new idea with the perfect or ideal, whereas, should we make the same comparison with present methods, we would find them lacking. That is, there are many points of the present mechanical governor that we may have trouble with—indeed, trouble is expected sooner or later.

Since the electric circuits have proved reliable and also since the electric circuits can be designed so as to give a continuous check upon the possibility of functioning properly when called upon, it appears that an electric system of frequency control will fulfill all the demands required.

The above methods of frequency control seem to have sufficient accuracy for the present demands on the Pacific Coast. However it might be interesting to bring out some suggested schemes that may be improvements, should they be properly worked out. An increase in load of a system causes the system to slow down, thus using some stored energy. This speed reduction is necessary for the automatic control devices to function. However, the additional load on the system causes an additional output momentarily, this being supplied by the stored energy. This will give an indication on a very sensitive wattmeter before the speed is reduced. Should the wattmeter sensitiveness to be sufficient to respond to this momentary increase in load, a contacting means similar to that of the Kelvin balance type wattmeter could be used to give the pilot valve an impulse proportional to the power change. In this case the correcting impulse would be given before the speed actually changed. This impulse would be arranged so as to be anti-hunt, thus not being a continuous impulse. However, another pair of contacts could be arranged so that, should a large change of power occur, a continuous impulse would be given. This would be of great advantage should the machine drop its load, in giving a continuous impulse so as to shut off the water.

There has been very little discussion regarding the operation of automatic frequency control devices under conditions of system instability. A successful automatic frequency control should operate properly even when, and perhaps especially when, the system is out of step.

Tests were made on frequency recorders and meters when the resultant of two frequencies was applied. The conclusions drawn from these tests were that the vibrating reed meter read both frequencies correctly, the normal single-indication recording and indicating meters gave an indication of the approximate average and the synchronous timer gave an indication considerably below the lower frequency. The actual readings varied from average frequency by an amount proportional to the two voltages. That is, if the voltages of the two frequencies were equal, the frequency indicated would be almost exactly the average, while with approximate zero voltage on one frequency the meter would read approximately the other frequency. Therefore, it can readily be seen that the importance of studying the condition of instability when applying automatic frequency control is very great.

With the present method of application of automatic frequency control it is possible with a case of instability to have the control of frequency an attempt to lift a high frequency higher. That is, should the normal frequency be 50, the frequency of the generators be 52, and the frequency of the load be 45, the controllers may read 49.5 and thus try to open the gates further. This is only a tendency under the present method of installation, because, should the speed rise to a value above normal, the governors would take the situation over and control the gate opening accordingly. This discussion, however, brings out the point that automatic frequency control does no good and perhaps has a harmful effect during the condition of instability.

This perhaps brings up another step in the evolution of automatic frequency control. Should the automatic frequency control apparatus obtain its energy from a small pilot generator on the shaft of the main generator, this difficulty would be overcome. This pilot generator should have the same number of poles so as to give the same frequency. With no connection to this pilot generator besides the frequency controller and recorder, there would be a very small amount of disturbance and the effect of surges, etc., would not come to these instruments at all. With this method only the actual speed of the machine would be transmitted to the controller without outside disturbances, so that a correct performance in correcting speed changes may be expected.

The present mechanical governors do the wrong thing at the time of system disturbances. The best method of controlling the speed of machines at this time would be to have an electromagnet operating on the pilot valves in such a way as to close the gates during the time of disturbances. This magnet could be operated by a negative sequency relay, a zero sequency relay or an underwatt relay. Under normal operating conditions there are no zero or negative sequence currents flowing; therefore relays of this nature could be set very sensitive. An underwatt relay could also be set so as to operate in a very fast manner. These relays should be so arranged that they would function only when the disturbance on the system was being automatically reset. With this arrangement, should a minor disturbance occur, the relays would be set so as not to function, but should a medium disturbance occur of sufficient magnitude to make it necessary to operate these relays, although the relays do operate momentarily, no harm is done, as the system will have only a slight speed drop for the moment. However, should a major disturbance occur that caused an increase in output, such as a single phase to ground resistance short circuit, it is very important to cut down the gate opening, thus preventing the system from pulling out of step. Instability is caused by the prime mover torque. The torque is greater at lower speeds and is less at less gate opening. Therefore the greatest benefit at the time of disturbances of this sort would be derived from closing the gates down to a point where the torque will not pull out.

All this discussion leads up to what may be called the ideal automatic frequency control system. Combining all these requirements into one system would be relatively easy under the last scheme. With a small pilot generator supplying the frequency impulse only to the frequency controller, the frequency controller then operates on an electric pilot valve. Then with the wattmeter method of giving impulses instantaneously on small changes of load, with its second contact that gives a continuous impulse on dropping of the load from a unit, the machine would close its gates immediately. There will also be a second contact on the frequency controller so as to give a continuous impulse on swings over a certain amount. The arrangement could be so interlocked as to avoid hunting and still maintain constant speed. Then again the closing magnet on the pilot valve could be used in connection with the zero and negative sequency relays. Also for differential protection of the generator this same magnet may be used in shutting down the unit.

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*Current Practice and Research in Hydro Development**

This subcommittee was instituted for the first time this year with three purposes in view: First, to provide material for active committee discussion at the meetings of the Engineering Section. Second, to provide an agency through which new developments relating to the subjects covered by previous committee reports may be brought to the attention of the members of the Association. Third, to bring up for discussion new subjects and new lines of work which may develop into subjects of sufficient scope to be handled by a separate subcommittee. In addition to a number of minor subjects that were discussed informally at committee meetings, several papers were presented on subjects relating to the work of the hydraulic power committee. The full text of these papers is not included in this report as most of them are to be published alsewhere and will thus become available.

A BRIEF summary of the papers presented before this subcommittee during the year follows:

Test of a 24-in. Diameter Butterfly Valve Under Free Discharge

This subject was presented by Clinton deWitt of the Pacific Gas and Electric Company. The purpose of the test was to investigate the discharge coefficient and the power necessary to operate a butterfly valve under conditions of free discharge and also to note its behavior as regards vibration. The test valve was installed at the end of 160 ft. of 30-in. pipe leading from a reservoir. The static head was 233 ft. A discharge measurement for maximum opening gave a discharge coefficient of 0.87, based on the net area of valve opening. The torque required to move the valve in either the opening or closing direction was measured at various positions from wide open to closed. The result indicates that considerably less power is required than was indicated from information previously available. A complete account of the test and its results is expected to be published shortly in *Engineering News Record.*

Riveted Type Joint Efficiency

This subject has been worked up by Walter Dreyer of the Pacific Gas and Electric Company as part of a revision of the reports of the national hydraulic power committee on penstocks, published in 1923. It will be published as a serial report of the Engineering Section of the National Electric Light Association. New types of high efficiency butt strap riveted joints have been worked out with efficiencies 2 to 5 per cent higher than the joint tabulated as N.E.L.A. standard in the 1923 penstock report. The paper gives in full detail the assumptions made in the design and the details and weight of the joints.

Longitudinal Reinforcing for Reinforced Concrete Hydraulic Structures

In the work of enlarging their Drum canal during 1927-28, the Pacific Gas and Electric Company replaced the Tahoe siphon of this canal with a reinforced concrete bench flume section 1,600 ft. in length, having inside dimensions of 10-ft. width by 7-ft. center depth. The side walls have a 5-in. top width and 7-in. bottom. The Drum canal is at an altitude of about 4,800 ft.

When constructed, this length of conduit was divided into four sections, each having a different degree of longitudinal reinforcement in the side walls. The first section has 0.27 per cent, the second 0.31 per cent and the third 0.47 per cent and the fourth 0.65 per cent. No expansion joints were provided. Before water was turned in, the shrinkage cracks were marked and stationed. During the first part of September, 1928, the section was inspected while carrying 500 sec.-ft. of water and the comparative size of cracks and amount of leakage noted.

At the time, the section having 0.25 per cent longitudinal wall reinforcement showed cracks which allowed leaks that permitted water to drip from a shoulder left by the outside forms at the bottom of the wall. These main cracks that showed a leak as described above or sufficient to wet the wall down to the bottom, were spaced in general from 15 to 25 ft. apart. In the section having 0.31 per cent reinforcement, the main wall cracks were spaced in general from 15 to 35 ft. apart, the leaks were smaller and in many cases the wall was only damp to the bottom. In the section having 0.47 per cent wall reinforcement the main cracks averaged about 25 ft. apart and the wall in the majority of cases was only wet or damp. In the section having 0.65 per cent wall reinforcement the cracks were very small and the wall was damp in very few places.

Since the amount of water dropped off to a small flow before the advent of cold weather, no observation has been obtained under winter conditions.

On May 22, 1929, an observation was made with over 500 sec.-ft. in the canal. The water temperature was 41 deg. F.

It was observed that in the section having 0.27 per cent longitudinal reinforcement, the leaks in general had increased and one in particular, which appeared to be at the end of a day's pour, had reached the proportions of approximately ½ g.p.m. Several leaks showed efflorescence and in one case disintegration, which was probably due to ice and frost action of winter.

An increase in leaks and damp spots was also observed in the section having 0.31 per cent reinforcement, although to a lesser degree. In both of the above sections the amount of leakage was considered undesirable for such structures as reinforced concrete flumes and bench flumes when severe winters prevail. The leakage in the first section could endanger certain types of soil foundations, where bench flumes are concerned.

The last two sections, having 0.47 per cent and 0.65 per cent reinforcement, showed satisfactory conditions, outside of an increase in number of sweat spots. The last section has few surface cracks for this type of construction. It is concluded that 0.27 per cent and 0.31 per cent longitudinal reinforcing is not sufficient for structures such as the above, when expansion joints are not used. Reinforcing of 0.5 per cent to 7 per cent without expansion joints is considered to give satisfactory results. Each problem will have its own economic solution, but for the heavier walls the lighter reinforcement (as 0.25 per cent) with water-tight expansion joints will probably be the most economic as well as the most satisfactory solution from the design standpoint.

Pressure Rise in Penstock Due to Emergency Closing of Penstock Valve

This was presented by R. M. Peabody of the Southern California Edison Company. The paper points out that pressure rises of considerable magnitude may result from closing penstock valves even at rather slow rate and under normal velocity and that the amount of pressure rise varies widely with the type of valve. Formulas are developed for the variation in flow during closure and for the application of the Allievi analysis to such conditions. Typical curves and diagrams illustrate the effect of various types of valves on

* Report of subcommittee on current practice and research in hydro development, hydraulic power committee, Engineering Section. Prepared by R. M. Peabody, Southern California Edison Company.

the pressure rise. The national hydraulic power committee has this paper under consideration for publication.

Study of Flow in the Mountain Tunnel, Hetch Hetchy Aqueduct

This paper was presented by L. W. Stocker, assistant city engineer of San Francisco.

This study concerns changes in the flow capacity of the Hetch Hetchy aqueduct tunnel through which water diverted from the Tuolumne River at Early intake is conducted to the Priest reservoir, which serves as forebay for the Moccasin power plant.

The tunnel has been in service four years, giving an average flow of about 725 sec.-ft. Considering the initial condition (August, 1925,) as 100 per cent, the flow capacity for a given fall of the hydraulic gradient is now 7.6 per cent less, and the fall required for a given quantity of water flowing is now 15 per cent greater.

The tunnel was inspected from end to end in December, 1928. The invert of the concrete-lined portions (59 per cent of the total length) was found much roughened by erosion, due to the sand and gravel carried through by the water. The mortar has been cut away more rapidly than the crushed rock fragments, leaving the latter projecting an average of about ⅛ in. The other physical changes being insignificant, practically the entire increase in resistance to flow is ascribed to the invert roughening.

The decrease in capacity appears to have progressed at varying rates until about May, 1928, since which time no further change is noted.

No method of restoring the lost capacity has as yet been determined on.

Values of coefficiencies in various hydraulic formulae are noted in the text and shown by curves accompanying.

Mr. Stockers' paper will be published in full by the American Society of Civil Engineers.

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*Flow Line Conduits**

The work of the subcommittee on flow line conduits was confined to the design and construction of flow tunnels, flow pipes and auxiliary structures. Last year's report covered open canals and bench flumes. Duplication of data already published was avoided as much as possible. Pressure tunnels and transitions in flow lines have been thoroughly covered in past reports. An attempt has been made to limit this report to late installations, embodying new features of design, rather than submit general information or data on lines that have been in service for many years.

Flow Tunnels

Flow Formulas and Coefficients—

KUTTER'S formula is satisfactory for the design of flow tunnels.

Following are some values of the "n" in Kutter's formula which have been used in the design of flow tunnels having unlined or lined sections with the designated type of lining:

Type of Lining	*"n"*
Unlined	0.033 to 0.035
Concrete	0.014 to 0.016
Granite	0.015
Timber	0.012 or 0.013

In the past, for well trimmed unlined sections a value of $n=0.030$ has been used, but the larger value of 0.035 is recommended.

Shape of Section—

The section for flow tunnels is partly determined by the material through which the tunnel is driven. For unlined tunnels, the section most generally used is approximately rectangular. The required size is, of course, generally determined by hydraulic requirements, but the actual shape is influenced by the kind of driving equipment and method of construction to be used.

For concrete lined tunnels, the section is generally a horseshoe shape. In heavy ground this shape gives the required strength in the arch, at the same time giving the necessary clearance for driving. This shape also presents advantages in the placing of concrete. In the case where the formation requires lining, in the larger sized tunnels, this section conforms to the more or less standard type of timbering.

Slope of Invert or Bottom—

Slope of invert of tunnel is determined by an economic study of cost of tunnel construction and value of head at power house, the total capacity having been determined.

In determining slopes and grade elevations of the bottom of a tunnel which is to have both lined and unlined sections in its length, care should be taken to see that the change from one section to the other can be readily made. It cannot be determined beforehand what percentage of a tunnel's length will be lined. This requires the careful consideration of the hydraulics and the computation of the elevation of the water surface for all conditions that may be met.

Number and Location of Adits—

Adits are used when economically available, but no general rule can be given for number and location.

The number of adits depends upon the time allowed to complete the tunnel and also the cost of hauling tunnel muck. The location of adits depends upon topography through which the tunnel passes and adits are usually placed on tunnel grade, with the adit portals at the shortest possible distance from the tunnel.

Horizontal and Vertical Cover—

Horizontal cover and vertical cover are relatively unimportant when compared to their usage in conjunction with pressure tunnels. In flow tunnels the vertical cover should have no effect on design, provided there is no pressure on the crown. Horizontal cover should be sufficient to take the hydrostatic force exerted on the side walls of the tunnel.

Grouting and Guniting to Prevent Leakage—

Grouting may be use effectively to prevent or stop leakage. Pressures up to 100 lb. per sq.in. have been used to force the grout into the voids between the rock and form concrete. Leakage in tunnels is not of great importance if they are part of a system composed largely of unlined ditches. The low pressures found in flow tunnels may not warrant expensive means of preventing leakage. Gunite has been extensively employed to patch up weak spots and occasional seams in the sides of section.

Necessity for Lining—

Necessity for lining a flow tunnel depends upon the condition of rock encountered. A tunnel should be lined if not in sound rock. If in sound rock the question of lining depends upon economic conditions. A lined tunnel has advantages over an unlined, as unnoticed rock seams will be filled and rendered waterproof. lining will also increase the structural strength of the section and make it liable to "cave in."

* Report of subcommittee on flow line conduits, hydraulic power committee, Engineering Section. J. W. Jourdan, chairman. C. R. Carlson, J. F. Davenport, J. R. Johnson, E. N. Murphy, C. M. Mardel, R. R. Robertson.

Timber Linings—

Timber linings may be employed as a matter of protection of rock section or to improve the hydraulic properties of the tunnel. Trouble with water getting behind the timbers is a serious objection against timber linings.

Plain Concrete to Prevent Leakage—

Plain concrete to prevent leakage has been found satisfactory for flow tunnels. The concrete must be sound and dense, however, as it has been found that soft, porous concrete develops pin hole leaks very quickly.

Partial lining for bottom and sides is sometimes employed in the case of flow tunnels where it has been decided to have a concreted section and where the hydraulic gradient is always below the springing line of the arch. Concrete lining for the crown would only be necessary where the rock is disintegrated and unstable, and the roof timbers removed or concreted in place.

The theory has been advanced of omitting the bottom lining, as the bottom erodes badly in many cases. By omitting the bottom lining and designing a correspondingly larger section, a saving may be effected.

Reinforced concrete lining for flow tunnels would only be employed to take care of external or collapsing pressure, either due to water or the rock formation itself.

Construction methods—

The construction method to be used is worked out for each particular job. The shape of section required for a particular tunnel may be altered to accommodate a certain type of driving equipment as well as from consideration of the necessity of permanent lining. In the case of many smaller tunnels, the available head is such that the minimum size of section is that which is required in order to obtain driving room.

The following construction methods were used on a long flow tunnel:

The tunnel has a nominal section, horseshoe in shape, with a flat floor 11 ft. 4 in. in width. The radius of the tunnel is 7 ft. 6 in. with its center located 6 ft. 2 in. from the bottom on the vertical centerline. Total length of tunnel is 22,676 ft. Four headings were driven simultaneously, two headings being driven from an intermediate camp located approximately half way between inlet and outlet portals. The full face heading system was used, 87 holes approximately 9 ft. long, being drilled by means of a "jumbo" on which were mounted ten pneumatic drills. Holes were blasted, using instantaneous and delay fuses, first removing the center plug and then the surrounding material, using the "curtain" method of timing shots in order to prevent any material save the center plug from traveling town the tunnel. Mucking was done by means of a Conway electric endless belt machine with power scoop. The machine handled about 15 yd. per hr. Progress at tunnel headings averaged 15 ft per day, through solid granite.

In removing muck the material would fall from the belt into a 3½-yd. dump car. It would be hauled away in a four-car train by a ten-ton electric locomotive, on 36-in. gage track, the tunnel being double tracked up to the heading, with empties on one track and loaded cars on the other.

Transportation facilities for construction were provided by building 4.4 miles of road to the exit portal, 11.4 miles of road to the intermediate adit, and an incline railway 2,700 ft. long which was used in erecting the steel siphon to the entrance portal.

A unique feature of this tunnel is the manner in which the flow of a creek, crossing the tunnel 155 ft. above the invert, is diverted. Considerable thought was spent on the scheme in order that the air compressed by the falling water be permitted to escape, and thus have no effect on the carrying capacity of the tunnel. The floor of the entrance chamber has never been examined to see if the impact from the falling water has formed potholes in the rock.

Flow Line Pipes and Siphons—

Williams and Hazen's and Kutter's formulas are used to compute the flow through steel flow pipes, with the former being favored for diameters under 2 or 3 ft. For the larger sized riveted steel pipe, up to 102 in. in diameter, Kutter's formula is very satisfactory.

The following coefficients have been used for the indicated type of pipe as shown below. These values are expected to obtain over a period of years.

Type	Kutter's "n"	W&H "C"
Small diam. butt-strap or slip joint-thin plate	0.014	90-100
Large diam. riveted		
up to 5/16 in. plate lap	0.014	
up to 7/16 in. plate butt-strap	0.014	
½ in. to 9/16 in. plate butt-strap	0.015	
5/8 in. to ¾ in. + plate butt-strap	0.016	

Kutter's "n" = 0.012 is used for welded steel pipe.

Velocity and slope of invert in a flow line depend to a great extent upon the topography through which the line passes. The slope of the invert is usually such that it will take care of entrance losses plus friction losses in the line itself.

Compensation of grade for bends is often neglected where bends are limited to a minimum radius equal to 2½ times the diameter of the pipe. This results in a negligible loss through bends. A generous value for "n" is sometime employed to allow for bends.

The economical diameter of a flow line depends upon the value of friction head. Flow lines are practically all of constant diameter and plate thickness. Thus the proper diameter and plate thickness can be determined with relative ease as compared with similar determinations for penstocks. The minimum thickness of plate seems to be 5/16 in. to ⅜ in. Transportation and handling of the pipe may dictate the minimum thickness of plate.

Allowable stress in flow pipe lines depends upon whether the line will be subjected to water hammer. If the line can never be subjected to water hammer 16,000 lb. per sq.in. combined stress may be allowed. This applies particularly to siphons where hoop tension due to water pressure will govern the thickness of plate. Penstock design practice, modified to fit conditions, may be used in designing and detailing flow line pipe and auxiliary features, such as expansion joints, air valves, supports and anchors.

Protection against rocks and slides is provided on the exposed flow line from Huntington Lake to Big Creek No. 1 of the Southern California Edison Company. The flow lines, one of which is back-filled, run along a side hill for some distance, and at a point where slides have occurred or are liable to occur, a concrete cover protects the exposed line. This has proved to be necessary as boulders weighing several tons have rolled down the hills during rain storms or spring thaws.

Siphons of small diameter are, as a rule, buried. The Drum siphon in the Drum canal of the Pacific Gas and Electric Company is about 1,900 ft. long, 102 in. in diameter, 5/16-in. plate, double lap riveted, and is buried in earth for about two-thirds of its diameter for its entire length. The siphons on the company's Tiger Creek conduit are placed on concrete and steel piers, which are designed in accordance with penstock standards. The formation where these siphons will be constructed is broken and solid rock.

Air valves or vents and blow-off valves are usually found on inverted siphons. Huntington-Shaver siphon across Big Creek has three 18-in. valves at both upstream and downstream ends. To date they have given satisfactory service and are free from any leakage when seated. A blow-off valve has been provided at the bottom of this siphon. This valve is of the needle type and is in series with a gate valve. Both are hand operated. Needle valves have been found to be very satisfactory for the purpose of draining the line due to the ease of operation under the high pressure existing which would render a gate valve inoperative without equalizing the pressure against its face.

Blow-off valves are installed at certain points so that in case of pipe failure near the low point of the line, the pipe

will not be collapsed. The siphon in the Lake Valley Cross-over canal of the Pacific Gas and Electric Company is 3,300 ft. long, is of 24-in. diam., No. 14 gage, riveted steel pipe, and was designed ultimately to carry 45 sec.-ft.

At the lower end of the Lake Valley Cross-over siphon mentioned above, the water is carried on down into the Drum canal by means of a pipe line about 1,050 ft. long, 15 in. in diameter at the upper end, and 14 in. in diameter at the lower end, the difference in elevation between the inlet and outlet being about 460 ft. This pipe was designed to discharge freely at the lower end, practically the total head being computed to be used in friction and velocity head, thus keeping the pressure head very low. This allowed the use of No. 12 gage steel. It was necessary to absorb the energy of the spouting water at the lower end by means of a baffle structure on the bank of the Drum canal.

One of the most unusual types of shut-off and regulating valves is found on the flow line from Huntington Lake to tunnel No. 7. This valve is of the shutter type with the two leaves butting together at the center line of the pipe. The advantage of a valve of this type comes from the shape and position of the rectangular jet. An unsymmetrical jet would cause the back-filled and unanchored line to vibrate, due to water swirl and impact while regulating the flow, under a 60-ft. head.

Water hammer in flow lines is usually negligible due to the position of surge chambers or surge pipes at the head of the penstocks. On water hammer tests conducted by the Southern California Edison Company on an experimental penstock with a forebay at the top of the line, it was found that the pressure wave was of zero magnitude at the forebay. With this fact in view, it is apparent that a water hammer wave in a penstock will lose its effectiveness by the time it reaches a flow line at the head of the penstock. A flow line isolated from a penstock could not be affected by water hammer save by a stop valve at the end of its line. Due to the fact that velocities in flow lines are relatively low in magnitude and that the stop valves or gates mentioned above are slow in closing in the majority of cases, water hammer should not affect the design of the line. Exemplifying the latter is the Mono-Bear siphon where a 102-in. butterfly valve is located at the downstream end of the siphon. Due to the relatively slow closing time of the valve and the moderate velocities through the siphon at this location, the effect of water hammer on pipe stress was considered negligible.

In all but the most unusual cases in the design of a flow line for internal pressure, a minimum plate thickness, as determined, gives sufficient strength for any external loading it is liable to be subjected to. A condition where the external pressure might govern design is where the back-filled pipe rests on solid rock, and where earth is not tamped under the line. Under such a condition, with the pipe partially filled or just filled, there is a tendency for radial distortion due to unequal pressure around the periphery of the pipe. Tension and bending will be present in the pipe shell and be greatest on the top and at points on the horizontal diameter. Such stress would no doubt limit the plate thickness and if the above conditions exist, the stresses at these points should be carefully considered. Back-fill loading on the pipe in this case would aggravate the condition mentioned.

Measures to keep pipe full to prevent corrosion were not taken on the Mono Creek flow line. The amount of water regulated by gate control determines when the flow line on the Huntington-Shaver diversion runs full. This particular feature was not considered in the design of either line.

Protection against freezing has been obtained on the Mono flow line and Mono-Bear siphon which is at over 7,000 ft. El., by back-filling the entire line under 4 ft. of cover. At the point where the line crosses the river, the pipe is lagged with two laminations of wooden planks between which are layers of tarred paper. Two layers of three-ply roofing felt covered with asphalt form an outer protective surface for the wooden lagging. This protection is necessary due to the small but extremely valuable flow through the line during the winter months.

The right-of-way for a flow line usually deviates from a ground contour by the amount of grade in order that excavation may be reduced to a minimum. An example of this is found on the Mono flow line which turns through 96 deg. in a distance of 70 ft. in order to follow a side hill contour. The width of the right-of-way will depend upon the size of the line, amount of construction road required, and the possibility of parallel lines in the future.

Roads are almost always used for the construction of flow lines, due to the fact that the lines are fairly level and a road is easily constructed on the same grade. Siphons, if constructed on steep grades, usually require inclines for their construction.

Tubercles or blisters forming on the interior of flow lines will affect capacity. As both Mono flow lines and Huntington-Shaver flow line have been in service less than three years, no noticeable effect has been observed in the change in capacity. Under conditions similar to that at Big Creek No. 1, where the flow line is always under pressure which varies with elevation at Huntington Lake, fouling of the interior of the line will cause a loss in effective head at the power house. This loss in head may become quite appreciable as time goes on. For this reason, cleaning and placing a smooth, protective, enamel coating on the interior will not only protect the line, but also help pay for the expense by the increase in effective head at the power house.

Field construction methods used on the Mono flow line are described as being typical. The pipe was trucked into the approximate location. On the road above the trench into which the pipe was to be placed, stood a Linkbelt steam shovel with a crane boom attached. The pipe section was lifted from the truck by the crane and placed in position in the trench. The pipe was then bolted together, and later riveted as the riveting crew of four men came along. Excavation and pipe delivery were controlling factors which limited production. A maximum of eleven 17-ft. sections were laid and 1,076 ⅞-in. rivets driven during one shift.

The Pacific Gas and Electric Company has a number of wood stave flow lines on the smaller canals. The value of "C" in Williams and Hazen's formula used in their design varied from 120 to 130. Small wood stave lines are generally supported on concrete or timber saddles. Such lines must be protected when subject to slides or rocks from above. The section of line which is empty when the flow is cut off, is of fir preservative treated, the rest of the line being untreated wood.

Reinforced Concrete Pipe

The Big Pine No. 3 hydro-electric plant of the Bureau of Power and Light system of the City of Los Angeles is supplied by a 45-in. precast circular concrete pipe for the flow line conveying water from the diversion works to the penstock.

The diversion works consist of a dam 5 ft. high, intake flume 6 ft. wide with grate bars and control gate, fish screen and leaf scraper, and a combination of settling tanks and bypass delivering the water to the 45-in. flow line. The flow line terminates in a forebay tank 10 ft. in diameter by 23.5 ft. deep with an overflow in case of surge and from which the steel penstock leads to the power house.

The flow pipe is a reinforced concrete pipe 45 in. inside diameter, 4,730 ft. long, with a slope of 0.0015. The walls of the pipe are 4¾ in. thick, reinforced with ten coils of ¼-in. wire to each 3-ft. section. Forms were rented and the pipe precast on the job in lengths of 36 in. The following equipment was used:

30 inside forms
30 outside forms
15 top rings
90 bottom rings
2 45-in. steel platforms
1 45-in. reinforcing platform

This permitted the construction of 30 lengths per day by stripping forms 24 hours after pouring and allowing the pipe section to cure for three days on the bottom ring. The pipe sections were then delivered to the trench where it was possible to reach it by road and rolled to their final location along the trench. This method of handling made it necessary to cut manholes in the pipe after installation. The concrete was cut away far enough to permit installation of frame with anchor bolts.

The rental cost of the metal forms was as follows:

Rental of forms	$ 714.00
Loading of forms	22.44
Freight and hauling	368.18
	$1,104.62

The original design was based upon a flow of 40 sec.-ft. with Kutter's "n" value of 0.012 resulting in a 42-in. pipe. However, 42-in. forms were not readily available while forms for 45-in. diameter were, so that 45 in. became the proper size from a cost standpoint with the added advantage of 20 per cent increase in carrying capacity.

The unit costs on this flow line, including in each item 18.1 per cent of field costs for overhead, were as follows:

Excavation, 5,810 cu.yd. at $2.64 or per lin.ft.	$ 3.31
Making pipe, 1,587 pieces (rental included lin.ft.)	6.22
Placing pipe, per lin.ft.	2.64
Back-fill 2,500 cu.yd. at $4.38 or per lin.ft.	2.36
Total average cost per lin.ft. of pipe	$14.53

This work was done during the summer of 1925.

The diversion works referred to above embrace two auxiliary structures consisting of a revolving fish screen and leaf scraper and also a set of three settling tanks and bypass conduit. (This fish screen was described in last year's report of the committee on flow line conduits.)

The sand trap and bypass are located between the leaf scraper of fish screen and the 45-in. flow line pipe. The sand trap consists of three bins with suitable baffle walls and 18-in. iron sluice gates delivering into the bed of the creek. A regulating gate at the head of the structure can divert the water from the sand boxes to a bypass channel leading direct to the flow line pipe. This bypass is 7 ft. wide, constructed on the bank of the creek, and the sand boxes are between it and the creek bed.

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*Maintenance of Hydraulic Works**

The idea of continuous operation at any cost has been so prominent in the minds of those responsible for the maintenance of hydro-electric systems that questions of efficiency and economies have been overlooked to a considerable degree. It is the purpose of this report to discuss some of the problems of maintenance of hydraulic works and to indicate the desirability of economic studies and efficiency measurements in certain instances.

Standard of Maintenance

CONTINUOUS operation requires a high standard of maintenance of all features which affect the reliability of hydro-electric plants. This applies especially to operating equipment, penstocks, tunnels, and other parts vital to the operation of the plant.

Equipment should be maintained in first-class operating condition at all times. Minutely detailed inspection should be made at regular intervals. Repairs should be made by high-grade mechanics. Generating units should be overhauled thoroughly at least once a year. Long life and continuous service are of such importance that the highest possible standard of maintenance of all operating equipment is justified.

The minimum maintenance of buildings and other power plant structures requires that deterioration of materials be prevented. Even this degree of maintenance is not attained in some cases and buildings are allowed to depreciate seriously. While this practice does not directly cause loss of output it is to be condemned. Neat, orderly appearance of structures and grounds has a value since it creates a favorable impression on the public and has a beneficial influence on the operating personnel. Men who pride themselves upon the appearance of the plant for which they are responsible are not apt to overlook defects in operation. Under normal conditions the standard of maintenance is set by the men in charge, although the demands of continuous service leave little leeway for the exercise of judgment except in the matter of appearance. Economic studies can be made of a few major maintenance items.

Maintenance of Efficiency and Capacity

Loss of efficiency results in an increase of operating expense unless surplus water is available and it should be closely watched, particularly in the larger plants where 1 per cent in efficiency may mean thousands of kilowatt-hours daily.

Mechanical inspection rather than test is the usual method of determining the necessity of repairs. If wicket gates, runners, needles, or buckets are worn sufficiently to affect their strength or proper operation they are renewed but efficiency is reduced long before the parts fail structurally. Many hydraulic units are equipped with venturi meters and regular checks of water against output are made to determine if capacity or efficiency has fallen off. Such tests are subject to inaccuracies due to errors in measuring head, quantity and output, but are very valuable in giving a continuous indication of efficiency and capacity. With large units a weekly capacity test is recommended. Records should be kept of the results and comparison made with previous readings to detect any reduction of efficiency or capacity.

Accurate field tests to determine the absolute efficiency of hydraulic units are expensive even when units are equipped with flow meters and such tests are seldom used in connection with maintenance work. Such tests are of great value in the operation of the units, however.

A detailed description of the various maintenance processes is beyond the scope of this report but it is of interest to indicate the principle parts of hydraulic plants which require maintenance as reported by the member companies of the Pacific Coast.

Dams—There are comparatively few parts of a dam which are subject to deterioration and maintenance is correspondingly small. Two companies report damage to concrete dams, due to spalling of concrete by frost action. Various coatings intended to prevent moisture entering the concrete have been tried with only moderate success. These coatings have in-

* Report of subcommittee on maintenance of hydraulic works, hydraulic power committee, Engineering Section. J. M. Gaylord, chairman, R. C. Denny, L. O. Murphy, C. C. Ruble, C. P. Vetter, E. J. Waugh, G. M. Wills.

cluded various asphalt emulsions, tar products, aluminum paint and membrane coatings, such as roofing felt. All of these coatings require maintenance each year.

One company reports the renewal in 1929 of the timber facing of a rock-fill dam. The original facing was placed in 1907 and 1908 and was of native Geoffrey pine which is quite inferior to most commercial lumber. The new facing is to be of redwood, supported by creosoted Douglas fir. Another company reports a life of fifteen to twenty years for wooden facings. At one reservoir the up-stream faces of the dam are being backfilled above the winter water line to prevent damage to the concrete.

Tunnels—Turning the water out of a power tunnel usually involves a considerable loss of power and the value of this power must be considered in planning maintenance work. Bad leaks must be repaired but minor leaks and loss of capacity may cost less than the necessary repairs. An interesting case arises at the Kern River No. 3 plant of the Southern California Edison Company where caddis worms on the tunnel linings reduce the capacity of the conduit. The effect is of importance only during the runoff period when water is available in excess of canal capacity. As warm weather approaches the condition becomes worse due to the growth of the worms but it does not pay to shut down the plant to clean the tunnels unless the saving in output during the remainder of the runoff is greater than the loss of output during the shutdown. An estimate of the remaining runoff and the length of the shutdown must show a reasonable saving before the work is approved.

Irrigation interests in many instances require that leakage be kept at a minimum, which necessitates repairs not justified by power considerations alone. Noticeable leaks or vegetation along the banks sometimes bring criticism which must be heard.

Broken concrete linings due to swelling ground or excessive pressure, leakage due to porous or defective concrete, fallen rocks and similar troubles are the principal items requiring maintenance. These things usually can be repaired easily once the tunnel is empty.

Pipe Lines—The location, design, and construction of penstocks are of greatest importance in their maintenance. An exposed penstock, properly supported on piers and painted inside and out usually can be properly maintained and should receive the same careful attention that is given operating equipment of the power station. The loss of power and difficulty of repainting the interior surfaces, particularly of small and steep pipes, makes it doubtful if such work is justifiable in many cases and an economic study of various alternatives should be made.

One company reports the repainting of the interior surfaces of two penstocks which had become so badly rusted that the loss of head was excessive. The saving in power and added pipe life amply justified the cost of the work.

Repainting the exterior surfaces of buried pipes involves the expense and risk of excavation, and is seldom attempted. Proper drainage of soil greatly increases the life of buried steel pipe.

Canals and Flumes—Proper maintenance of canals and flumes includes the safety of structures, lining and banks, the maintenance of carrying capacity, the prevention of wear of metal flume sheets and the prevention of leakage. The safety of the structures and banks is largely left to the judgment of the maintenance men but other repairs calling for the unwatering of the conduit must be considered from the cost standpoint as in the case of tunnels. Removal of silt and vegetable growths from canals can be accomplished to some extent with water in the canals but thorough cleaning can be done only with an empty canal. Leakage through porous lining and banks is troublesome in many cases and must be held down to a reasonable minimum by patching, plastering or guniting concrete linings or by silting or suitable treatment of the inner surfaces of earth canals.

The maintenance of wooden flumes requires frequent patrol and inspection. Leakage through joints in the flume box, failure of boards, side posts and cross ties, leakage around headwalls and sagging of flume due to failure of footings or supports must be carefully watched. Old wooden flumes may require patrolling as often as twice a day to anticipate and prevent disastrous breaks.

The maintenance of steel flumes is much less expensive. Wear of sheets at the bottom of the flume due to sand is a question receiving attention at this time. It appears to be very much worth while to cover the flumes at the bottom with a protective coating which will resist the abrasion and which can be renewed at reasonable expense when necessary. With the small amount of leakage from steel flumes, footings and supporting structures are kept dry and require less maintenance.

Impulse Wheels—Impulse wheels have few wearing parts and maintenance work is comparatively simple. Needle tips and throat rings require frequent renewal even with comparatively clear water. Steel parts with hard metal coatings are being used in many plants. This type of construction, while high in first cost, shows excellent wearing qualities. The use of special steels for the parts also promises good results. Buckets, if made of proper material, have long life in clear water, but wear is greatly accelerated by silt and sand in the water. The life of buckets varies from a few weeks to fifteen yaers or more according to conditions.

Reaction Turbines—Reaction turbines have more wearing parts and are more difficult to maintain than impulse wheels. Seal ring clearance increases in operation and rings should be changed when this reaches the allowable maximum. Wicket gates become worn by water and silt and permit leakage to such an extent as to interfere with the proper starting and stopping of the unit. Runners wear and in some cases fail by cavitation or pitting. All of these parts must be renewed when inspection shows poor condition or tests indicate loss of efficiency.

Governors—The increasing use of synchronous electric clocks has produced a demand for closer speed regulation and system time control. The quality of speed control depends to a large extent on the condition of the governors and more careful maintenance of these parts is required. Regulating valves must be kept in perfect condition and lost motion in all parts of the governor must be kept at a minimum if precise regulation is to be attained.

The Maintenance Program

In a system comprised of a large number of generating units the planning of maintenance becomes important. Advantage must be taken of seasonal variations in stream flow and in power demand to take units out of service for maintenance work when the value of the power lost will be a minimum. If there are several units in a plant, units can be repaired without loss of power during the low water season but if a plant is operated by stored water it may be advisable to do the repair work during the high water season when stream-flow plants will be operating at maximum capacity. In a combined steam and hydro system, due consideration must be given to the requirements of maintenance work on steam units to the end that the entire maintenance program may be accomplished with a minimum cost for lost power and adequate generating capacity kept in service at all times. For best results it is advisable to plan the work six months or more in advance. Such planning facilitates the budgeting of maintenance expenses and is in line with best modern practice.

Adequate records of repairs should be kept in the station files. A complete history of each important piece of equipment will often assist in diagnosing trouble and deciding on repairs. It is an important source of information in con-

sidering the desirability of special features of design. In small stations a simple log book of repair work usually is sufficient but in large plants an "equipment history" file covering all important apparatus is desirable.

Replacement of Units

Maintenance of the system comprises not only routine repairs paid for as a part of current expense, but also includes the replacement of complete units of complete plants which is properly covered by depreciation reserve. Such replacements involve the retirement from capital of the old units and addition to capital of the new equipment or plant.

The Southern California Edison Company in 1929 replaced one complete plant and one generating unit in another plant. The unit replaced had a capacity of 500 kw. and was installed in 1905, giving an actual life of 24 years. The prime mover was an obsolete type of turbine. The controlling reasons were obsolescence, low efficiency, saving in operating expense due to automatic operation of the new unit and the fact that the canal capacity was slightly in excess of the installed turbine capacity, making a larger unit desirable.

The plant replaced was built in 1899 and contained three 450-kw. units. In this case it was possible to demonstrate a sufficient saving in operating expense and gain in output to justify the expenditure for new construction. The units were driven by an obsolete type of impulse wheel. There were no governors and constant attendance was necessary. The equipment was in poor mechanical condition. Estimates showed a considerable saving in operating expense, also a gain in output due to increased efficiency and additional head on the new unit.

A complete replacement of a 10,000-kw. plant is now under consideration and a brief analysis of the problem may be of interest. The plant was built in 1905 and contains five 2,000-kw. units. The head is 262 ft. and the over-all operating efficiency is 15.5 kw. per sec.-ft. The firm power is 1,500 kw. and the present average annual output 54,000,000 kw.-hr.

The cost of continuing the operation of the present plant for the next 20 years was estimated assuming a moderate increase above present costs each year and including at various intervals certain extraordinary expenses such as replacement of runners, transformers, valves, etc.

In order to determine the uniform equivalent operating cost, the present worth of these various operation and maintenance costs was determined, assuming 6 per cent compound interest. This process gave a sum which would take care of all expenses as they might arise in the operation of the plant. The average uniform rate of spending the principal and interest in the 20-year period considered can be found in annuity tables and is the desired figure to be used as the average cost of operation and maintenance. To this cost was added the cost of steam standby power including operation, maintenance and fuel costs.

In the same way the average uniform cost of operating the new plant was estimated. The saving in operating expense plus the value of the additional power to be obtained from the new plant represents the total benefit to be secured from the proposed replacement. This annual saving must pay interest and depreciation on the new money to be spent and thus determines the maximum permissible expenditure for reconstruction.

New Designs

The number of units, the arrangement of penstocks and valves, and the details of machine design all have important bearings on maintenance and these points require careful study in the designing office. Studies should be made balancing the cost of duplicate capacity and refinements of design against possible savings in maintenance costs and losses due to outages of equipment. Plants are only built to operate and the best design is that which permits minimum maintenance costs and most reliable operation.

*Mechanical Reliability of Hydro-Electric Units**

The report of the subcommittee on mechanical reliability of hydro-electric units this year is a continuation of the detailed study and analysis of data covering the operation of hydro-electric generating units in Pacific Coast plants. This is the sixth year of a continuing study of these records.

THE subcommittee on mechanical reliability of hydro-electric units presents herewith the sixth annual report on the operation of generating units within the territory of the Pacific Coast Electrical Association. The same word of caution in studying and analyzing the report that has prefaced previous reports must again be emphasized, and the reader should bear in mind that care must be taken in the forming of conclusions, because a full knowledge of the factors which have caused large or unusual outages is necessary before direct comparisons of equipment can be made. Outages may be due to faulty design, installation or operation, but it is not practical to differentiate the contributing causes in a tabular report without an extensive supplementary explanatory history. In comparing results, therefore, care must be taken that injustice is not done to a manufacturer whose equipment may have been improperly installed or operated or that a poor machine, well maintained and operated is not put above a good machine which is improperly maintained and operated. The report as presented is a truly representative cross-section of general conditions and the results herein set down are average and what may well be expected in practice over a period of time.

* Report of subcommittee on mechanical reliability of hydro-electric units, hydraulic power committee, Engineering Section. D. P. Dinapoli, Pacific Gas and Electric Company, chairman. R. E. Ballew, E. M. Breed, P. H. Gilbert, J. W. Jourdan, B. N. Merritt, Harry Olsen, L. M. Perrin, C. P. Rhine, R. R. Robinson, G. M. Wills.

The addition of each year's record of operation adds to the value of the report, because the irregularities of infrequent and periodical overhauls and renewals become smoothed out in the averages of a long period of time and the final statistics represent the probable performance of the equipment in service.

The report for the year 1929 covers a total of 71 units installed in 31 plants and having a grand total of 1,651,380 hp. There are 33 vertical turbine units with a total rating of 772,480 hp. driving vertical generators rated at 613,200 kva. The horizontal shaft units were divided among four turbines with a total rating of 64,700 hp. and 34 impulse wheels with a total rating of 814,200 hp. driving 38 horizontal generators with a total rating of 673,919 kva. The vertical turbines range in size from 10,500 hp. to 44,000 hp. and average 23,400 hp. Speeds vary from 171.4 r.p.m. to 600 r.p.m. and static heads from 157 to 820 ft. The impulse wheels range in size from 9,500 hp. to 56,000 hp. with an average of 23,950 hp. Speeds vary from 143 r.p.m. to 514 r.p.m. and static heads from 880 ft. to 2,563 ft.

The following tabular data show the operation of the units for the year 1929 together with the previous five years of operation and present the total and average kilowatt-hours generated as well as the segregated outage hours listed in accordance with the cause of outage. Brief footnotes indicate the nature of unusual outages, but it has not been possible to include detailed explanations. The report is well worth the time required for its complete study and affords an illuminating insight into the reasons for outages. Some are of a minor nature but frequently occurring, others are major casualties. The former are generally subject to correction when their nature is determined and better performance of equipment will result. The latter cannot usually be forestalled and are in the nature of unforseen accidents which are unpreventable.

TABLE II—Hydro-Electric Plant Operating Record For 1929

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
							Analysis of Idle Time								
Plant Index Number	Kilowatt Rating of Each Generator	Year	Kilowatt Hours Generated	Average Service Time	Average Idle Time	Total	Average Total Outage Time (9)+(10)	Average Outage Time When in Demand	Average Outage Time When Not in Demand	Average Reserve Time (6)—(8)	Average Demand Time (5)+(9)	Maximum Possible Service Time (5)+(11)	Average Capacity Factor (4) / (2)x8.760	Average Output Factor (4) / (2) x (5)	Average Service Demand Availability Factor (5) / (12)
1	13,500	1929	49,675,050	72.18	27.82	100	3.98	0.02	3.96	23.84	72.20	96.02	0.420	0.582	1.000
2	16,000	1929	86,404,500	82.33	17.67	100	0.26	0.01	0.25	17.41	82.34	99.74	0.616	0.749	1.000
3	10,000	1929	25,484,000	99.77	0.23	100	0.23	0.00	0.23	0.00	99.77	99.77	0.291	0.291	1.000
4	10,000	1929	40,504,000	99.78	0.22	100	0.22	0.00	0.22	0.00	99.78	99.78	0.463	0.463	1.000
5	31,500	1929	134,947,000	55.73	44.27	100	0.16	0.00	0.16	44.11	55.73	99.84	0.489	0.878	1.000
6	24,300	1929	117,346,667	79.82	20.18	100	0.97	0.00	0.97	19.21	79.82	99.03	0.551	0.691	1.000
7	11,360	1929	60,563,700	95.72	4.28	100	4.25	0.03	4.22	0.04	95.75	95.76	0.608	0.636	1.000
8	8,480	1929	41,214,000	99.93	0.07	100	0.00	0.00	0.00	0.07	99.93	100.00	0.555	0.556	1.000
9	25,000	1929	141,541,000	69.87	30.13	100	15.15	0.40	14.75	14.98	70.27	84.85	0.646	0.925	0.994
10A	22,500	1929	69,294,000	52.79	47.21	100	4.44	0.09	4.35	42.77	52.88	95.56	0.352	0.666	0.998
10B	31,500	1929	106,872,683	83.43	16.57	100	4.14	0.00	4.14	12.43	83.43	95.86	0.679	0.814	1.000
11	15,750	1929	66,725,000	63.15	36.85	100	0.16	0.16	0.00	36.69	63.31	99.84	0.484	0.766	0.998
12A	10,000	1929	76,038,250	95.65	4.35	100	3.45	0.22	3.24	0.90	95.86	96.55	0.868	0.907	0.999
12B	10,000	1929	62,825,500	91.85	8.15	100	0.44	0.01	0.43	7.70	91.86	99.55	0.717	0.781	1.030
13	12,150	1929	34,043,500	50.75	49.25	100	8.93	0.00	8.93	40.32	50.75	91.07	0.320	0.630	1.000
14	14,000	1929	39,131,500	54.79	45.21	100	3.32	0.48	2.84	41.88	55.27	96.67	0.319	0.582	0.991
15	6,400	1929	20,097,000	72.24	27.76	100	7.98	0.00	7.98	19.78	72.24	92.02	0.358	0.496	1.000
21	10,000	1929	38,889,800	72.16	27.84	100	3.57	3.45	0.13	24.27	75.60	96.43	0.444	0.615	0.954
22	12,000	1929	28,571,400	67.45	32.55	100	26.80	0.00	26.80	5.74	67.45	73.19	0.272	0.403	1.000
23	6,250	1929	13,795,000	99.48	.52	100	0.22	0.22	0.00	0.31	99.70	99.79	0.254	0.255	0.998
31	20,000	1929	153,350,333	96.97	3.03	100	2.14	0.52	1.62	0.89	97.49	97.86	0.875	0.903	0.995
32	20,000	1929	73,680,850	67.90	32.10	100	2.77	0.00	2.77	29.33	67.90	97.23	0.421	0.620	1.000
33	6,000	1929	25,654,500	62.67	37.33	100	26.66	0.00	26.66	10.67	62.67	73.34	0.488	0.779	1.000
34	10,000	1929	29,901,800	97.01	2.99	100	1.43	0.00	1.43	1.56	97.01	98.57	0.341	0.352	1.000
35A	12,000	1929	31,263,600	83.09	16.91	100	9.91	0.00	9.91	7.00	83.09	90.09	0.297	0.358	1.000
35B	12,000	1929	33,547,200	84.35	15.65	100	8.79	0.00	8.79	6.86	84.35	91.21	0.319	0.378	1.000
35C	12,000	1929	46,615,200	93.72	6.28	100	3.04	0.00	3.04	3.24	93.72	96.96	0.443	0.473	1.000
36A	14,000	1929	70,450,000	83.78	16.22	100	3.68	0.00	3.68	12.55	83.78	96.33	0.574	0.686	1.000
36B	15,750	1929	65,339,000	72.97	27.03	100	1.29	0.00	1.29	25.74	72.96	98.71	0.474	0.650	1.000
36C	25,000	1929	133,788,000	82.32	17.68	100	2.88	0.71	2.17	14.81	83.03	97.13	0.611	0.742	0.992
37A	14,000	1929	82,017,720	86.23	13.77	100	5.14	0.14	5.00	8.63	86.37	94.86	0.669	0.776	0.998
37B	15,750	1929	69,941,620	74.90	25.10	100	1.95	0.00	1.95	23.15	74.90	98.05	0.507	0.677	1.000
37C	40,000	1929	87,779,400	41.32	58.68	100	17.16	0.00	17.16	41.52	41.32	82.84	0.251	0.606	1.000
37D	40,000	1929	80,445,000	38.92	61.08	100	3.06	0.00	3.06	58.03	38.92	96.95	0.230	0.590	1.000
38	4,000	1929	32,354,812	75.49	24.51	100	0.06	0.03	0.02	24.45	75.53	99.94	0.923	1.223	1.000
39	12,500	1929	18,575,000	92.73	7.27	100	0.72	0.72	0.00	6.55	93.45	99.28	0.170	0.183	0.993
40	31,000	1929	101,387,000	53.60	46.40	100	3.88	3.65	0.23	42.55	57.20	96.15	0.374	0.697	0.936
41A	10,000	1929	14,428,700	77.05	22.95	100							0.165	0.214	.....
41B	20,000	1929	71,655,100	77.68	22.32	100							0.409	0.526	.....
42	17,500	1929	114,622,000	85.76	14.24	100	5.20	0.00	5.20	9.04	85.76	94.80	0.748	0.872	1.000
*Avg. Hydro Units	16,373	1929	65,911,992	77.17	22.83	100	4.96	0.29	4.67	17.87	77.46	95.04	0.485	0.638	0.986

*Plants No. 41A and 41B are not included in the averages.

TABLE I—Hydro-Electric Plant Data

Index Number	Kind of Operation	Units Covered	Rated Hp.	Year	Static Head	Number Runners	R. P. M.	Setting	Generator KVA	Generator P. F.	Pressure Control	Shut-Off Valve Type	Shut-Off Valve Size	Shut-Off Valve Control	Governor Oil System	Governor Drive
								Vertical Turbine Installations								
1	Daily peak	2	20,000	1925	157.0	1	171.4	Plate steel spiral	15,000	0.90	Surge chamber	Butterfly	140	Motor	Individual	Belt
2	Run of river	2	23,400	1928	607.0	1	514.0	Cast steel spiral	20,000	0.80	Surge chamber and relief valve	Butterfly	72	Motor and hand	Individual	Belt
3	Daily peak	1	15,000	1921	216.8	1	225.0	Cast iron spiral	12,500	0.80	Pressure regulator	Butterfly	90	Motor	Individual	Belt
4	Base load	1	15,000	1921	197.9	1	225.0	Cast iron spiral	12,500	0.80	Flume spillway	Gates at Dam	...	Motor	Individual	Belt
5	Run of river	2	40,000	1922	454.0	1	257.0	Cast steel spiral	35,000	0.90	Pressure reg. and surge chamber	Butterfly	108	Motor	Central	D. C.
6	Daily peak	3	33,000	1925	315.0	1	225.0	Cast steel spiral	27,000	0.90	Pressure reg. and surge chamber	Butterfly	108	Motor	Individual	Gear
7	R. of R. and D. P.	3	15,000	1920	350.0	1	360.0	Cast steel spiral	14,200	0.80	Pressure reg. and surge chamber	Butterfly	84	Motor	Individual	D. C.
8	Run of river	1	12,000	1921	272.0	1	257.0	Plate steel spiral	10,600	0.80	Pressure reg. and surge chamber	Butterfly	90	Motor	Individual	D. C.
9	R. of R. and D. P.	3	35,000	1923	818.0	1	428.0	Cast steel spiral	28,000	0.894	Pressure reg. and surge chamber	Plunger	54	Hydraulic, hand and motor	Central	Belt
10A	Daily peak	1	30,000	1921	715.0	1	428.0	Cast steel spiral	25,000	0.90	Pressure reg. and surge chamber	Plunger	72	Hydraulic, hand and motor	Central	Belt
10B	Daily peak	1	44,000	1929	715.0	1	375.0	Cast steel spiral	35,000	0.90	Pressure reg. and surge chamber	Butterfly	84x72	Motor and hand	Central	Gear
11	Run of river	2	25,000	1921	820.0	1	500/600	Cast steel spiral	17,500	0.90	Pressure regulator	Plunger	60	Hydraulic, hand and motor	Central	Belt
12A	Base load	4	16,500	1909	460.0	1	400.0	Cast steel spiral	10,000	1.00	Pressure reg. and surge pipe	Gate	60	Motor	Central	Belt
12B	Base load	2	18,500	1914-16	460.0	1	400.0	Cast steel spiral	12,500	0.80	Pressure reg. and surge pipe	Butterfly	72	Hydraulic	Central	Belt
13	Seasonal peak	2	17,690	1927	225.0	1	277.0	Riveted steel spiral	13,500	0.90	Pressure regulator	Butterfly	102	Motor	Individual	Gear
14	Daily peak	2	20,900	1920	535.0	1	428.0	Cast iron spiral	17,500	0.80	Pressure reg. and surge chamber	Johnson	72	Hydraulic	Central	Belt
15	Base load	1	10,500	1928	197.0	1	257.0	Cast steel spiral	8,000	0.80	Relief valve	Butterfly	72	Motor	Individual	Gear
								Horizontal Turbine Installations								
21	Daily peak	2	18,600	1918-22	125.0	2	200.0	Plate steel spiral	12,500	0.80	None	Gates at intake	...	Motor	Individual	Belt
22	Daily peak	1	20,000	1917	519.0	1	360.0	Cast steel spiral	15,000	0.80	Pressure regulator	Butterfly	66	Motor	Individual	Belt
23	Run of river	1	7,500	1924	245.4	1	400.0	Cast steel spiral	6,520	1.00	Relief valve	Butterfly	...	Hydraulic	Individual	Belt
								Impulse Water-Wheel Installations								
31	Base load	3	30,000	1921-24	1,108.0	2	171.4		22,223	0.90	Pressure reg. and surge chamber	Gate	42	Hydraulic	Central	Motor
32	Base load and D. P.	2	35,000	1927	2,563.0	2	450.0		25,000	0.80	Surge chamber and by pass needle	Gate	26	Hydraulic and motor	Central	Belt
33	Base load	1	9,500	1921	1,865.0	1	514.0		7,500	0.80	Jet deflector	Gate	24	Motor	Individual	Belt
34	Daily and seasonal	2	14,000	1923	1,750.0	1	300.0		12,500	0.80	Pressure reg. and surge chamber	Gate	28	Hydraulic	Individual	Belt
35A	Daily peak	2	18,000	1913	1,375.0	2	360.0		12,500	0.96	Deflecting nozzles	Gate	36	Water motor	Central	Belt
35B	Daily peak	1	18,000	1922	1,375.0	2	360.0		15,000	0.80	Deflecting nozzles	Gate	36	Water motor	Central	Belt
35C	Daily peak	1	18,000	1928	1,375.0	1	257.0		15,000	0.80	By pass needle	Gate	36	Water motor	Central	Gear
36A	Daily peak	2	20,000	1913	2,080.0	2	375.0		17,500	0.80	Relief valve and by pass needle	Gate	24	Hydraulic hand	Central	Belt
36B	Daily peak	1	22,500	1923	2,080.0	2	375.0		17,500	0.90	Relief valve and by pass needle	Johnson	24	Hydraulic	Central	Belt
36C	Daily peak	1	35,000	1925	2,080.0	2	300.0		28,000	0.804	Relief valve and by pass needle	Plunger	30	Hydraulic and motor	Central	Belt
37A	Daily peak	3	22,500	1913	1,855.0	2	375.0		17,500	0.80	Relief valve and by pass needle	Gate	24	Hydraulic and hand	Central	Belt
37B	Daily peak	3	22,500	1923-25	1,855.0	2	375.0		17,500	0.90	Relief valve and by pass needle	Plunger	24	Hydraulic—motor	Central	Belt
37C	Daily peak	1	56,000	1928	2,418.0	2	250.0		45,000	0.89	Surge chamber and jet deflector	Gate	34	Hydraulic, motor-hand	Central	Belt
37D	Daily peak	1	56,000	1928	2,418.0	2	250.0		45,000	0.89	Surge chamber and jet deflector	Gate	34	Hydraulic, motor	Central	Gear
38	Run of river	4	10,750	1907	880.0	2	250.0		5,000	0.80	Deflecting nozzle	Gate	28	Hand and motor	Individual	Chain
39	Daily peak	1	14,000	1924	1,673.0	1	360.0		12,500	1.00	Jet deflector	Gate	...	Water motor	Individual	Belt
40	Run of river	1	40,000	1927	2,381.0	2	360.0		33,000	0.94	Pressure reg. and surge chamber	Gate	32	Hydraulic	Individual	Belt
41A	Daily peak	1	16,000	1923	930.0	2	200.0		12,500	0.80	Surge chamber and by pass needle	Needle valve	57	Hydraulic	Central	Belt
41B	Daily peak	1	32,200	1928	930.0	2	143.0		25,000	0.80	Surge chamber and jet deflector	Needle valve	57	Hydraulic	Central	Belt
42	Base load and D. P.	4	25,000	1925	1,315.0	2	257.0		20,000	0.875	Surge chamber and by pass needle	Gate	36	Hydraulic	Individual	Belt

TABLE III—Hydro-Electric Plant Operating Record—1924-29

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
							Analysis of Idle Time								
Plant Index Number	Kilowatt Rating of Each Generator	Year	Kilowatt Hours Generated	Average Service Time	Average Idle Time	Total	Average Total Outage Time (9) (10)	Average Outage Time When in Demand	Average Outage Time When Not in Demand	Average Reserve Time (6)—(8)	Average Demand Time (5) ∟ (9)	Maximum Possible Service Time (5) ∟ (11)	Average Capacity Factor (4) / (2)x8,760	Average Output Factor (4) / (2) x (5)	Average Service Demand Availability Factor (5) / (12)
		1925	24,640,450	63.20	36.80	100	18.60	18.60	0.00	18.20	81.80	81.40	0.520	0.797	0.772
		1926	52,432,500	72.90	27.10	100	2.58	2.42	0.16	24.52	75.32	97.42	0.443	0.608	0.968
1	13,500	1927	73,814,300	80.90	19.10	100	0.41	0.06	0.35	18.69	80.96	99.59	0.624	0.772	0.999
		1928	67,833,000	84.23	15.77	100	0.35	0.07	0.28	15.42	84.30	99.65	0.572	0.679	0.999
		1929	49,675,050	72.18	27.82	100	3.98	0.02	3.96	23.84	72.20	96.02	0.420	0.582	1.000
	Weighted	Avg.	60,570,970	74.68	25.32	100	5.18	4.23	0.95	20.13	78.92	98.82	0.516	0.688	0.948
2	16,000	1928	55,233,000	92.48	7.52	100	0.36	0.36	0.00	7.16	92.84	99.64	0.587	0.635	0.996
		1929	86,404,500	82.33	17.68	100	0.26	0.01	0.25	17.41	82.34	99.74	0.616	0.749	1.000
	Weighted	Avg.	77,127,250	87.40	12.60	100	0.31	0.18	0.12	12.28	87.59	99.69	0.601	0.692	0.998
		1924	28,706,000	98.90	1.10	100	0.91	0.91	0.00	0.19	99.81	99.09	0.326	0.331	0.991
		1925	28,304,000	97.80	2.20	100	1.10	0.71	0.40	1.10	98.51	98.90	0.323	0.331	0.994
		1926	23,412,000	97.60	2.40	100	2.14	0.00	2.14	0.26	97.60	97.86	0.267	0.274	1.000
3	10,000	1927	26,557,000	96.99	3.01	100	3.01	0.00	3.01	0.00	96.99	96.99	0.303	0.312	1.000
		1928	26,635,000	97.00	3.00	100	3.00	0.00	3.00	0.00	96.98	97.00	0.303	0.312	1.000
		1929	25,464,000	99.77	0.23	100	0.23	0.00	0.23	0.00	99.77	99.77	0.291	0.291	1.000
		Avg.	26,512,999	98.01	1.99	100	1.73	0.27	1.46	0.26	98.28	98.27	0.300	0.310	0.998
		1924	48,121,000	97.30	0.70	100	0.41	0.41	0.00	0.29	99.71	99.59	0.548	0.552	0.996
		1925	46,341,000	93.90	6.10	100	0.548	0.365	0.182	5.552	94.26	99.45	0.529	0.563	0.996
		1926	43,324,000	97.10	2.90	100	2.88	0.00	2.88	0.02	97.10	97.12	0.494	0.509	1.000
4	10,000	1927	44,826,000	95.57	4.43	100	4.43	0.00	4.43	0.00	95.57	95.57	0.512	0.536	1.000
		1928	43,925,000	96.86	3.14	100	3.14	0.00	3.14	0.00	96.86	96.86	0.500	0.516	1.000
		1929	40,504,000	99.78	0.22	100	0.22	0.00	0.22	0.00	99.78	99.78	0.462	0.463	1.000
		Avg.	44,506,834	97.08	2.92	100	1.94	0.13	1.81	0.98	97.21	98.06	0.508	0.523	0.999
		1926	131,161,500	57.70	42.30	100	0.46	0.00	0.46	41.84	57.70	99.54	0.475	0.823	1.000
		1927	152,223,500	73.11	26.89	100	0.00	0.00	0.00	26.89	73.11	100.00	0.552	0.755	1.000
5	31,500	1928	149,144,500	69.71	30.29	100	0.51	0.00	0.51	29.78	69.72	99.49	0.539	0.772	1.000
		1929	134,947,000	55.73	44.27	100	0.16	0.00	0.16	44.11	55.73	99.84	0.489	0.878	1.000
		Avg.	141,869,125	64.06	35.94	100	0.28	0.00	0.28	35.66	64.06	99.72	0.514	0.807	1.000
		1926	117,280,000	70.80	29.20	100	6.33	0.00	6.33	22.87	70.80	93.67	0.551	0.778	1.000
		1927	128,280,000	79.91	20.09	100	2.94	0.00	2.94	17.15	79.91	97.06	0.602	0.753	1.000
		1928	125,673,333	83.13	16.87	100	3.08	0.00	3.08	13.79	83.13	96.92	0.589	0.708	1.000
		1929	117,346,667	79.82	20.18	100	0.97	0.00	0.97	19.21	79.82	99.03	0.551	0.691	1.000
6	24,300	Avg.	122,145,000	78.42	21.58	100	3.33	0.00	3.33	18.26	78.41	96.67	0.573	0.732	1.000
		1924	36,208,333	76.80	23.20	100	3.32	0.06	3.26	19.88	76.86	96.68	0.363	0.473	0.999
		1925	66,613,999	95.90	4.10	100	3.20	0.21	2.99	0.90	96.10	96.80	0.669	0.698	0.998
		1926	63,823,333	93.60	6.40	100	1.99	0.24	1.75	4.41	93.84	98.01	0.641	0.685	0.998
7	11,360	1927	69,710,700	98.44	1.56	100	0.23	0.23	0.00	1.33	98.67	99.77	0.701	0.712	0.987
		1928	67,470,667	96.20	3.80	100	1.51	0.17	1.34	22.29	96.37	98.49	0.676	0.703	0.998
		1929	60,563,700	95.72	4.28	100	4.25	4.03	4.22	0.04	95.75	95.76	0.608	0.636	1.000
		Avg.	60,731,790	92.78	7.22	100	2.42	0.82	2.26	8.14	92.93	97.58	0.609	0.651	0.998
		1924	29,437,000	99.80	0.20	100	0.025	0.025	0.00	0.18	99.82	99.98	0.335	0.336	1.000
		1925	50,239,000	92.00	8.00	100	7.22	7.22	0.00	0.78	99.22	92.78	0.667	0.736	9.027
		1926	43,687,000	99.20	0.80	100	0.12	0.12	0.00	0.68	99.32	99.88	0.588	0.593	0.999
8	8,480	1927	59,494,000	97.86	2.14	100	1.50	1.48	0.02	0.64	99.34	98.50	0.800	0.818	0.986
		1928	41,504,000	97.50	2.50	100	2.39	2.39	0.00	0.14	99.86	97.64	0.557	0.572	0.976
		1929	41,214,000	99.93	0.07	100	0.00	0.00	0.00	0.07	99.93	100.00	0.555	0.556	1.000
		Avg.	44,262,500	97.72	2.28	100	1.88	1.87	0.00	0.42	99.58	99.30	0.584	0.602	0.981
		1924	78,223,547	45.16	54.84	100	18.02	0.71	17.31	36.82	45.87	81.98	0.356	0.789	0.985
		1925	No Report	.....	.....	...	.....	.....	.....	.....	.....	.....	.....	.....	.....
		1926	137,239,920	64.69	35.31	100	2.75	0.00	2.75	32.56	64.69	97.25	0.627	0.969	1.000
9	25,000	1927	173,524,333	80.79	19.21	100	1.54	0.02	1.52	17.67	80.81	98.46	0.792	0.980	1.000
		1928	148,483,000	72.96	27.04	100	7.45	3.33	4.12	19.59	76.29	92.55	0.676	0.928	0.956
		1929	141,541,000	69.87	30.13	100	15.15	0.40	14.75	14.98	70.27	84.85	0.646	0.925	0.994
		Avg.	135,802,200	66.69	33.31	100	8.98	0.89	8.98	24.32	67.59	91.02	0.602	0.918	0.987
		1924	21,997,194	38.07	61.93	100	11.36	8.74	2.62	50.57	46.81	88.64	0.111	0.292	0.813
		1925	124,018,312	81.51	18.49	100	2.46	2.34	0.12	16.03	83.85	97.54	0.629	0.772	0.972
		1926	133,547,683	78.13	21.87	100	6.78	6.52	0.26	15.09	84.65	93.22	0.678	0.867	0.923
10A	22,500	1927	177,007,475	91.33	8.67	100	1.72	0.13	1.59	6.95	91.46	98.28	0.898	0.984	0.998
		1928	182,737,000	91.99	8.01	100	2.77	0.00	2.77	5.24	91.99	97.23	0.924	1.005	1.000
		1929	69,294,000	52.79	47.21	100	4.44	0.09	4.35	42.77	52.88	95.56	0.352	0.666	0.998
		Avg.	118,100,280	72.30	27.70	100	4.92	2.97	1.95	22.78	75.27	95.08	0.599	0.764	0.951
10B	31,500	1929	106,872,683	83.43	16.57	100	4.14	0.00	4.14	12.43	83.43	95.86	0.679	0.814	1.000
		1924	50,602,500	51.28	48.72	100	24.87	0.92	23.95	23.85	52.20	75.13	0.366	0.713	0.982
		1925	88,756,757	77.63	22.37	100	0.41	0.41	0.00	21.96	78.04	99.59	0.643	0.929	0.995
		1926	73,679,500	72.55	27.45	100	1.74	1.37	0.37	25.71	73.92	98.26	0.534	0.735	0.981
11	15,750	1927	93,222,500	76.91	23.09	100	2.35	0.16	2.19	20.74	77.07	97.65	0.676	0.878	0.998
		1928	70,224,500	63.96	36.04	100	2.98	0.24	2.74	33.06	64.20	97.02	0.507	0.793	0.996
		1929	66,725,000	63.15	36.85	100	0.16	0.16	0.00	36.69	63.31	99.84	0.484	0.766	0.998
		Avg.	73,868,460	69.25	30.75	100	5.42	0.54	4.88	27.0	68.12	94.58	0.535	0.786	0.992
		1926	65,820,000	91.47	8.53	100	7.48	0.81	6.67	1.05	92.28	92.52	0.751	0.821	0.991
		1927	76,170,750	95.75	4.25	100	1.17	0.02	1.15	3.08	95.77	98.83	0.869	0.908	1.000
12A	10,000	1928	65,806,750	89.30	10.70	100	6.90	0.00	6.90	3.82	89.28	93.12	0.749	0.839	1.000
		1929	76,038,250	95.65	4.35	100	3.45	0.22	0.24	0.90	95.78	96.55	0.868	0.907	0.999
		Avg.	70,958,938	93.04	6.96	100	4.75	0.26	3.74	2.21	93.28	95.26	0.809	0.869	0.998
		1926	66,238,000	98.46	1.54	100	0.33	0.29	0.04	1.21	98.75	99.67	0.756	0.768	0.997
		1927	68,470,500	93.89	6.11	100	0.76	0.00	0.76	5.35	93.89	99.24	0.782	0.833	1.000
12B	10,000	1928	67,594,500	97.80	2.20	100	1.24	0.00	1.24	0.92	97.84	98.72	0.769	0.878	1.000
		1929	62,825,500	91.85	8.15	100	0.44	0.01	0.43	7.70	91.86	99.55	0.717	0.781	1.000
		Avg.	66,282,125	95.50	4.50	100	0.69	0.08	0.62	3.80	95.58	99.30	0.756	0.792	0.999
		1927	16,625,000	48.00	52.00	100	11.17	0.00	11.17	40.83	48.00	88.83	0.310	0.645	1.000
13	12,150	1928	33,891,500	62.13	37.87	100	7.81	0.00	7.81	30.05	62.14	92.18	0.317	0.511	1.000
		1929	34,043,500	50.75	49.25	100	8.93	0.00	8.93	40.32	50.75	91.07	0.320	0.630	1.000
	Weighted	Avg.	33,728,333	53.63	46.37	100	9.30	0.00	9.30	37.07	53.63	90.69	0.316	0.595	1.000
		1927	35,419,500	58.65	41.35	100	0.00	0.00	0.00	41.35	58.65	100.00	0.289	0.492	1.000
14	14,000	1928	No Report	.....	.....	...	.....	.....	.....	.....	.....	.....	.....	.....	.....
		1929	39,131,500	54.79	45.21	100	3.32	0.48	2.84	41.88	55.27	96.67	0.319	0.582	0.991
		Avg.	37,275,500	56.72	43.28	100	1.66	0.24	1.42	41.61	56.96	98.34	0.304	0.537	0.995
15	6,400	1929	20,097,000	72.24	27.76	100	7.98	0.00	7.98	19.78	72.24	92.02	0.358	0.496	1.000
		1925	56,376,800	82.00	18.00	100	7.86	5.92	1.94	10.14	87.92	92.14	0.643	0.784	0.932
		1926	46,078,800	75.90	24.10	100	0.13	0.01	0.12	23.97	75.91	99.87	0.526	0.693	1.000
21	10,000	1927	64,621,350	81.34	18.66	100	0.54	0.24	0.30	18.12	81.58	99.46	0.738	0.907	0.997
		1928	55,981,000	83.69	16.31	100	2.81	2.73	0.08	13.50	86.42	97.19	0.637	0.762	0.968
		1929	38,889,800	72.16	27.84	100	3.75	3.45	0.13	24.27	75.60	96.43	0.444	0.615	0.954
		Avg.	52,389,550	79.02	20.98	100	3.02	2.47	0.51	18.00	81.69	97.10	0.598	0.752	0.970
		1924	19,056,600	82.70	17.30	100	0.50	0.50	0.00	16.80	83.20	99.50	0.181	0.219	0.994
		1925	47,626,200	96.00	4.00	100	0.52	0.18	0.34	3.48	96.18	99.48	0.453	0.472	0.998
		1926	28,944,000	79.50	20.50	100	20.50	3.42	17.15	0.00	82.92	79.50	0.275	0.346	0.960
22	12,000	1927	34,894,800	92.18	7.82	100	2.11	0.00	2.11	5.71	92.18	97.89	0.332	0.360	1.000
		1928	40,014,000	82.12	17.88	100	3.03	0.00	3.03	14.84	82.13	96.96	0.379	0.462	1.000
		1929	28,561,400	67.45	32.55	100	26.80	0.00	26.80	5.74	67.45	73.19	0.272	0.403	1.000
		Avg.	33,184,500	83.33	16.68	100	8.91	0.68	8.24	7.76	84.01	91.09	0.315	0.377	0.992

TABLE III—Hydro-Electric Plant Operating Record—1924-29

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
							Analysis of Idle Time								
Plant Index Number	Kilowatt Rating of Each Generator	Year	Kilowatt Hours Generated	Average Service Time	Average Idle Time	Total	Average Total Outage Time (9) - (10)	Average Outage Time When in Demand	Average Outage Time When Not in Demand	Average Reserve Time (6)—(8)	Average Demand Time (5)+(9)	Maximum Possible Service Time (5)+(11)	Average Capacity Factor (4) (2)x8,760	Average Output Factor (4) (2) x (5)	Average Service Demand Availability Factor (5) (12)
		1926	17,810,000	95.10	4.90	100	3.92	3.92	0.00	0.98	99.02	96.08	0.325	0.342	0.961
		1927	23,881,000	97.52	2.48	100	1.95	1.95	0.00	0.53	99.42	98.05	0.436	0.447	0.980
23	6,250	1928	16,407,000	99.40	1.00	100	0.56	0.56	0.00	0.43	99.57	99.43	0.299	0.302	0.994
		1929	13,795,000	99.48	0.52	100	0.22	0.22	0.00	0.31	99.70	99.79	0.254	0.255	0.998
		Avg.	15,473,250	97.78	2.22	100	1.66	1.66	0.00	0.56	99.43	98.37	0.328	0.336	0.983
		1926	119,470,260	90.71	9.29	100	1.49	0.27	1.22	7.80	90.98	98.51	0.682	0.752	0.997
		1927	75,520,330	85.42	14.58	100	3.92	0.06	3.86	10.66	85.48	96.08	0.431	0.504	0.999
31	20,000	1928	117,613,600	94.30	5.70	100	1.66	0.00	1.66	4.02	94.32	98.32	0.666	0.706	1.000
		1929	153,350,333	96.97	3.03	100	2.14	0.52	1.62	0.89	97.49	97.86	0.875	0.903	0.995
		Avg.	116,338,606	91.85	8.15	100	2.30	0.21	2.09	5.84	92.07	97.69	0.664	0.716	0.998
32	20,000	1928	57,158,400	72.60	27.40	100	1.05	0.00	1.05	26.38	72.57	98.98	0.647	0.892	1.000
		1929	73,680,850	67.90	32.10	100	2.77	0.00	2.77	29.33	67.90	97.23	0.421	0.620	1.000
	Weighted	Avg.	93,998,825	70.25	29.75	100	1.91	0.00	1.91	27.85	70.24	98.10	0.534	0.756	0.100
		1924	22,894,300	98.00	2.00	100	1.63	1.63	0.00	0.37	99.63	98.37	0.434	0.443	0.984
		1925	34,609,800	81.90	18.10	100	2.01	0.12	1.89	16.09	82.02	97.99	0.659	0.804	0.999
		1926	25,201,000	61.90	38.10	100	0.02	0.00	0.02	38.08	61.90	99.98	0.478	0.772	1.000
33	6,000	1927	17,984,100	43.84	56.16	100	1.47	0.00	1.47	54.69	43.84	98.53	0.342	0.780	1.000
		1928	23,576,800	55.03	44.97	100	1.21	0.00	1.21	43.76	55.03	98.79	0.447	0.813	1.000
		1929	25,645,500	62.67	37.33	100	26.66	0.00	26.66	10.67	62.67	73.34	0.488	0.779	1.000
		Avg.	24,986,750	67.22	32.78	100	5.50	0.29	5.21	27.28	67.52	94.50	0.475	0.732	0.997
		1925	39,424,065	73.07	26.93	100	3.62	1.79	1.83	23.31	74.86	96.38	0.450	0.616	0.976
		1926	37,873,920	85.41	14.59	100	4.09	4.09	0.00	10.50	89.50	95.91	0.432	0.506	0.954
34	10,000	1927	No Report	.....	.....	...	.....	.....	.....	.....	.....	.....	.....	.....	.....
		1928	44,486,500	78.61	21.39	100	11.01	0.00	11.01	10.38	78.61	88.99	0.506	0.644	1.000
		1929	29,901,800	97.01	2.99	100	1.43	0.00	1.43	1.56	97.01	98.57	0.341	0.352	1.000
		Avg.	37,921,571	83.53	16.47	100	5.04	1.47	3.57	11.44	85.00	94.96	0.448	0.530	0.983
		1926	33,417,200	88.00	12.00	100	2.23	0.57	1.66	9.77	88.57	97.77	0.318	0.361	0.995
		1927	28,866,875	84.68	15.32	100	11.56	0.00	11.56	3.76	84.68	88.44	0.273	0.322	1.000
35A	12,000	1928	41,712,800	88.32	11.68	100	2.73	0.00	2.73	8.95	88.32	97.27	0.396	0.448	1.000
		1929	31,263,600	83.09	16.91	100	9.91	0.00	9.91	7.00	83.09	90.09	0.297	0.358	1.000
		Avg.	33,815,120	86.02	13.98	100	6.61	0.14	6.46	7.37	86.14	93.39	0.321	0.372	0.999
		1926	33,417,200	88.00	12.00	100	2.23	0.57	1.66	9.77	88.57	97.77	0.318	0.361	0.995
		1927	28,407,000	86.70	13.30	100	8.52	0.00	8.52	4.78	86.70	91.48	0.270	0.312	1.000
35B	12,000	1928	41,305,000	79.40	20.60	100	9.77	0.00	9.77	10.83	79.40	90.23	0.390	0.490	1.000
		1929	33,547,200	84.35	15.65	100	8.79	0.00	8.79	6.86	84.35	91.21	0.319	0.378	1.000
		Avg.	34,169,100	84.61	15.39	100	7.33	0.14	7.18	8.06	84.75	92.67	0.326	0.385	0.999
35C	12,000	1928	36,558,600	92.84	7.16	100	2.13	0.00	2.13	5.03	93.39	97.87	0.690	0.744	1.000
		1929	46,615,200	93.72	6.28	100	3.04	0.00	3.04	3.24	93.72	96.96	0.443	0.473	1.000
	Weighted	Avg.	59,866,200	93.28	6.72	100	2.58	0.00	2.58	4.14	93.55	97.42	0.566	0.608	1.000
		1925	67,684,333	69.40	30.60	100	0.85	0.03	0.82	29.75	69.43	99.15	0.552	0.797	0.999
		1926	74,095,000	77.50	22.50	100	7.09	0.00	7.09	15.41	77.50	92.91	0.604	0.780	1.000
36A	14,000	1927	No Report	.....	.....	...	.....	.....	.....	.....	.....	.....	.....	.....	.....
		1928	103,652,500	91.38	8.62	100	3.42	0.00	3.42	5.20	91.38	96.58	0.842	0.922	1.000
		1929	70,450,000	83.78	16.22	100	3.68	0.00	3.68	12.55	83.78	96.33	0.574	0.686	1.000
		Avg.	78,970,458	80.52	19.48	100	3.76	0.01	3.75	15.73	80.52	96.24	0.643	0.796	0.999
		1925	67,684,333	69.40	30.60	100	0.85	0.03	0.82	29.75	69.43	99.15	0.492	0.708	0.999
		1926	74,095,000	77.50	22.50	100	7.09	0.00	7.09	15.41	77.50	92.91	0.537	0.693	1.000
36B	15,750	1927	99,812,000	92.13	7.87	100	2.25	0.00	2.25	5.62	92.13	97.75	0.723	0.784	1.000
		1928	109,231,000	94.41	5.59	100	2.02	0.00	2.02	3.57	94.41	97.98	0.789	0.836	1.000
		1929	65,339,000	72.97	27.03	100	1.29	0.00	1.29	25.74	72.96	98.71	0.474	0.650	1.000
		Avg.	83,232,267	81.28	18.72	100	2.70	0.01	2.69	16.10	81.29	97.30	0.603	0.734	0.999
		1925	72,900,000	71.90	28.10	100	0.97	0.37	0.60	27.13	72.27	99.03	0.579	0.806	0.995
		1926	116,300,000	64.50	35.50	100	2.90	0.00	2.90	32.60	64.50	97.10	0.531	0.823	1.000
36C	25,000	1927	155,590,000	82.85	17.15	100	3.00	0.00	3.00	14.15	82.85	97.00	0.710	0.857	1.000
		1928	179,490,000	87.18	12.82	100	2.28	0.00	2.28	10.53	87.18	97.71	0.817	0.937	1.000
		1929	133,788,000	82.32	17.68	100	2.88	0.71	2.17	14.81	83.03	97.13	0.611	0.742	0.992
	Weighted	Avg.	142,033,600	77.75	22.25	100	2.41	0.22	2.19	19.84	77.97	97.59	0.650	0.833	0.997
		1924	37A and 37B Not Given Separately			...	.....	.....	.....	.....	.....	.....	.....	.....	.....
		1925	66,953,000	77.50	22.50	100	1.05	1.05	0.00	21.45	78.55	98.95	0.546	0.705	0.988
		1926	90,855,465	89.20	10.80	100	1.65	0.00	1.65	9.15	89.20	98.35	0.741	0.831	1.000
37A	14,000	1927	No Report	.....	.....	...	.....	.....	.....	.....	.....	.....	.....	.....	.....
		1928	112,494,780	92.27	7.73	100	5.50	0.00	5.50	2.23	92.27	94.50	0.915	0.992	1.000
		1929	82,017,720	86.23	13.77	100	5.14	0.14	5.00	8.63	86.37	94.86	0.699	0.776	0.998
		Avg.	88,080,240	86.30	13.70	100	3.34	0.30	1.79	10.36	86.60	96.66	0.750	0.826	0.996
		1924	37A and 37B Not Given Separately			...	.....	.....	.....	.....	.....	.....	.....	.....	.....
		1925	59,482,800	81.32	18.68	100	1.29	1.29	0.00	17.39	82.61	98.71	0.431	0.530	0.984
		1926	76,904,340	84.18	15.82	100	1.35	0.00	1.35	14.47	84.18	98.65	0.557	0.662	1.000
37B	15,750	1927	107,169,740	95.91	4.09	100	1.93	0.04	1.89	2.16	95.95	98.07	0.777	0.810	0.999
		1928	106,642,760	90.66	9.34	100	2.52	0.00	2.52	6.82	90.66	97.48	0.770	0.850	1.000
		1929	69,941,620	74.90	25.10	100	1.95	0.00	1.95	23.15	74.90	98.05	0.507	0.677	1.000
		Avg.	84,028,252	85.39	14.61	100	1.81	0.27	1.54	12.40	85.66	98.19	0.608	0.706	0.997
37C	40,000	1929	87,779,400	41.32	58.68	100	17.16	0.00	17.16	41.52	41.32	82.84	0.251	0.606	1.000
37D	40,000	1929	80,445,000	38.92	61.08	100	3.06	0.00	3.06	58.03	38.92	96.95	0.230	0.590	1.000
		1925	8,985,984	88.70	11.30	100	5.02	3.46	1.56	6.28	92.16	94.98	0.257	0.289	0.962
		1926	7,750,936	80.57	19.43	100	2.44	2.44	0.00	16.99	83.01	97.56	0.221	0.275	0.970
38	4,000	1927	No Report	.....	.....	...	.....	.....	.....	.....	.....	.....	.....	.....	.....
		1928	33,466,750	81.11	18.89	100	1.63	1.06	0.57	17.26	82.17	98.37	0.952	1.174	0.987
		1929	32,354,812	75.49	24.51	100	0.06	0.03	0.02	24.45	75.53	99.94	0.923	1.223	1.000
		Avg.	20,639,621	81.47	18.53	100	2.29	1.75	0.54	16.24	83.22	97.71	0.588	0.740	0.980
		1926	18,776,000	62.74	37.26	100	0.00	0.00	0.00	37.26	62.74	100.00	0.171	0.273	1.000
		1927	28,649,000	84.38	15.62	100	0.79	0.00	0.79	14.83	84.38	99.21	0.262	0.311	1.000
39	12,500	1928	19,449,000	90.60	9.40	100	0.01	0.01	0.00	9.39	90.61	99.99	0.177	0.196	0.999
		1929	18,575,000	92.73	7.27	100	0.72	0.72	0.00	6.55	93.45	99.28	0.170	0.183	0.993
		Avg.	21,362,250	82.61	17.39	100	0.38	0.18	0.19	17.01	82.80	99.62	0.195	0.241	0.998
		1927	102,481,250	87.50	12.50	100	11.55	6.30	5.26	0.95	93.80	88.45	0.439	0.502	0.933
40	31,000	1928	117,378,000	97.20	2.80	100	1.80	1.80	0.00	1.01	98.99	98.21	0.431	0.444	0.982
		1929	101,387,000	53.60	46.40	100	3.88	3.65	0.23	42.55	57.20	96.15	0.374	0.697	0.936
	Weighted	Avg.	113,888,332	79.43	20.57	100	5.74	3.92	1.83	14.84	83.33	94.27	0.415	0.548	0.950
		1927	31,730,900	66.83	33.17	100	0.00	0.00	0.00	33.17	66.83	100.00	0.362	0.542	1.000
41A	10,000	1928	No Report	.....	.....	...	.....	.....	.....	.....	.....	.....	.....	.....	.....
		1929	14,428,700	77.05	22.95	100	.....	.....	.....	.....	.....	.....	0.165	0.214	.....
		Avg.	23,079,800	71.94	28.06	100	.....	.....	.....	.....	.....	.....	0.264	0.378	.....
41B	20,000	1929	71,655,100	77.68	22.32	100	.....	.....	.....	.....	.....	.....	0.409	0.526	1.000
42	17,500	1929	114,622,000	85.76	14.24	100	5.20	0.00	5.20	9.04	85.76	94.80	0.748	0.872	1.000

TABLE V—Analysis of Outage Hours—Horizontal Turbine Installations.

Item Cause	Plant Index Number 21						22							23				
Year	1925	1926	1927	1928	1929	Average	1924	1925	1926	1927	1928	1929	Average	1926	1927	1928	1929	Average
13. General Hydraulic Causes,																		
(a) Ice or trash	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	6.25	.....	.....	1.56
(b) Floods	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
(c) Penstock or canal	.....	.....	4.40	.....	347.60	70.40	9.00	15.00	.....	16.00	5.00	1,088.00	118.83	.....	40.50	.....	.....	10.12
(d) Headgates or intake	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4.25	7.75	.....	.....	3.00
(e) Other general hydraulic	.....	.....	.....	.....	.....	.....	.....	.....	17.00	.....	.....	.....	2.83	21.00	8.28	.....	2.50	7.94
(f) Total General Hydraulic	0.00	0.00	4.40	0.00	347.60	70.40	9.00	15.00	17.00	16.00	5.00	1,088.00	191.66	25.25	62.78	0.00	2.50	22.63
14. Water Wheels and Auxiliaries,																		
(a) Runner	.....	.....	.....	.....	.....	.....	2.00	.....	.....	134.00	.....	.....	22.66	86.20	.....	.....	.....	21.55
(b) Shut-off valve	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	28.58	1.89	.....	.....	7.62
(c) Turbine gates or needle nozzle	.....	.....	.....	.....	2.50	0.50	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
(d) Guide bearings or main bearings	9.00	.....	7.37	7.45	255.30	55.82	22.00	.....	.....	.....	.....	.....	.....	6.90	.....	.....	.....	1.72
(e) Thrust bearing	.....	.....	.....	.....	.....	.....	.....	.....	.....	23.00	.....	.....	3.67	.....	.....	.....	.....	.....
(f) Governor and governor system	15.30	5.30	.....	.....	12.00	6.52	.....	.....	.....	.....	.....	.....	.....	11.95	5.90	.....	.....	.....
(g) Pressure regulator or deflectors	.....	1.00	.....	.....	.....	0.20	1.00	.....	.....	.....	2.00	1,080.00	180.50	9.70	.....	2.85	1.20	4.46
(h) Draft tube	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1.25	.....	.....	.....	.31
(i) Lubrication system	.....	.....	1.50	6.35	.....	1.57	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
(j) Vibration	.....	3.00	.....	.....	.....	0.60	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
(k) Seal rings	.....	.....	5.47	1.50	.....	1.39	.....	.....	.....	8.00	8.00	.....	2.67	173.00	.....	35.72	14.90	55.90
(l) Inspection	.....	3.00	.....	.....	4.20	1.44	3.00	.....	21.00	.....	.....	.....	4.00	.....	.....	1.40	.....	0.35
(m) General overhauling and replacement	.....	.....	.....	.....	.....	.....	.....	.....	1,755.00	.....	244.00	178.00	362.85	.....	.....	.....	.....	.....
(n) Other causes	7.57	.....	.....	1.33	.....	1.76	.....	.....	.....	.....	.....	.....	.....	.....	87.73	.....	.....	21.93
(o) Total Water Wheel	31.87	12.30	14.34	16.63	274.00	69.83	28.00	0.00	1,776.00	165.00	254.00	1,258.00	580.25	317.58	95.52	39.97	16.10	117.30
15. Generator and Appurtenances,																		
(a) Vibration	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
(b) Lubrication or oil leakage	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
(c) Rotor or field	.....	11.20	.....	.....	.....	2.24	3.00	.....	.....	.....	.....	.....	0.50	1.00	6.00	.....	0.40	1.85
(d) Armature iron or windings	1,344.42	.....	.....	477.87†	.....	364.46	.....	.....	.....	.....	.....	.....	.....	.....	.....	8.15	.....	2.04
(e) Exciter and rheostats	.....	0.16	0.38	0.27	0.10	0.18	.....	10.00	3.00	4.00	.....	2.00	3.17	.....	.....	1.00	.....	0.25
(f) Ventilation system	.....	.....	74.32*	.....	.....	14.86	.....	17.00	.....	.....	.....	.....	2.83	.....	.....	.....	.....	.....
(g) Cleaning	.....	.....	.....	.....	.....	.....	2.00	2.00	6.00	.....	7.00	.....	2.83	.....	.....	.....	.....	.....
(h) Inspection	.....	.....	.....	0.03	0.20	0.04	.....	2.00	.....	.....	.....	.....	0.33	.....	.....	.....	.....	.....
(i) Other causes	.....	.....	.....	.....	3.10	0.62	2.00	.....	.....	.....	.....	.....	0.33	.....	6.57	.....	0.10	1.66
(j) Total Generator	1,344.42	11.36	74.70	478.17	3.40	382.40	7.00	31.00	9.00	4.00	7.00	2.00	10.00	1.00	12.57	9.15	0.50	5.80
16. Total All Causes—(13+14+15)	1,376.29	23.66	93.44	494.80	625.00	522.63	44.00	46.00	1,802.00	185.00	266.00	2,348.00	781.90	343.83	170.87	49.12	19.10	145.73
17. Number of Units Covered	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1
18. Average Outage Hours per Unit	688.15	11.83	46.72	247.40	312.50	261.32	44.00	46.00	1,802.00	185.00	266.00	2,348.00	781.90	343.83	170.87	49.12	19.10	145.73

*—Installing new fans.
†—Rewind Unit No. 1.

TABLE IV—Analysis of Hydro-Electric Plant Outage Hours—Vertical Turbine Installations

Item Cause	Plant Index Number / Year	1 1925 (5 mos.)	1926	1927	1928	1929	Avg.(b)	2 1928 (8 mos.)	1929	Avg. (b)	1924	1925
13. General Hydraulic Causes,												
(a) Ice or trash		.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
(b) Floods		.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
(c) Penstock or canal		.....	.....	.....	.....	.....	.....	20.52	.....	15.39	.....	.....
(d) Headgates or intake		.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
(e) Other general hydraulic		23.23	.....	.....	.....	.....	11.15	.....	.....	.....	.....	.....
(f) Total General Hydraulic		**23.23**	**0.00**	.....	**0.00**	.....	**11.15**	**20.52**	.....	**15.39**	**0.00**	**0.00**
14. Water-Wheels and Auxiliaries,												
(a) Runner		1,316.62	400.67	.....	.....	373.60	786.80	.....	.....	.....	.....	.....
(b) Shut-off valve		.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
(c) Turbine gates or needle nozzle		.....	.....	.....	4.42	.....	0.88	.....	.....	.....	.....	.....
(d) Guide bearings or main bearings		.....	19.43	.....	.....	.....	3.89	.....	.....	.....	4.00	2.00
(e) Thrust bearing		.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
(f) Governor and governor system		.....	22.67	57.95	25.92	4.20	22.15	9.05	6.20	9.89	1.00	4.00
(g) Pressure regulator or deflectors		.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
(h) Draft tube		.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
(i) Lubrication system		.....	.....	.....	.....	1.50	0.30	.....	4.90	2.45	10.00	.....
(j) Vibration		.....	4.40	.....	.....	.....	0.88	.....	.....	.....	.....	.....
(k) Seal rings		.....	.....	.....	13.63	.....	2.73	.....	.....	.....	.....	.....
(l) Inspection		8.42	.....	7.00	10.00	5.80	8.60	2.80	4.40	4.30	2.00	.....
(m) General overhauling and replacement		.....	.....	.....	.....	297.60	59.53	.....	17.70	8.85	.....	.....
(n) Other causes		.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
(o) Total Water-Wheel		**1,325.04**	**447.17**	**64.78**	**53.97**	**682.70**	**885.78**	**11.85**	**33.20**	**25.49**	**17.00**	**6.00**
15. Generator and Appurtenances,												
(a) Vibration		.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
(b) Lubrication or oil leakage		.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	3.00
(c) Rotor or field		.....	.....	.....	.....	.....	.....	8.08	.....	6.06	.....	.....
(d) Armature iron or windings		.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
(e) Exciter and rheostats		.....	1.83	8.05	.....	3.10	2.60	0.85	.....	0.64	1.00	23.00
(f) Ventilation system		.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
(g) Cleaning		.....	.....	.....	8.00	.....	1.60	.....	.....	.....	31.00	34.00
(h) Inspection		.....	4.00	.....	.....	.....	0.80	0.57	11.40	6.13	31.00	30.00
(i) Other causes		.....	.....	.....	.....	12.90	2.58	.....	1.30	0.65	.....	1.00
(j) Total Generator		**0.00**	**5.83**	**8.05**	**8.00**	**16.00**	**7.58**	**9.50**	**12.70**	**13.48**	**63.00**	**91.00**
16. Total All Causes—(13+14+15)		**1,348.27**	**453.00**	**72.83**	**61.97**	**698.70**	**904.51**	**41.87**	**45.90**	**54.36**	**80.00**	**97.00**
17. Number of Units Covered		**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**1**	**1**
18. Average Outage Hours Per Unit		**674.14**	**226.50**	**36.42**	**30.98**	**349.40**	**452.25**	**20.93**	**22.90**	**27.18**	**80.00**	**97.00**

a—Repairs to tail race due to pressure regulator discharge washing away concrete.
b—Weighted.
c—Line Shaft.
d—Straightening Gen. Shaft.
e—Addition of Unit.
f—Completing Construction.
g—Details of outage not given.
h—Efficiency Tests.

TABLE VI—Analysis of Hydro-Electric Plant Outage Hours—Impulse Water-Wheel Installation

Item Cause	Plant Index Number / Year	31 1926	1927	1928	1929	Avg.	32 1928 (6 mos.)	1929	Avg.(b)	1924	1925	1926
13. General Hydraulic Causes,												
(a) Ice or trash		.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
(b) Floods		.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
(c) Penstock or canal		2.95	.....	.....	.....	0.74	.....	.....	.....	73.00	157.00	.....
(d) Headgates or intake		.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
(e) Other general hydraulic		.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
(f) Total General Hydraulic		**2.95**	**0.00**	**0.00**	**0.00**	**0.74**	**0.00**	**0.00**	**0.00**	**73.00**	**157.00**	.....
14. Water-Wheels and Auxiliaries,												
(a) Runner		5.83	0.42	.....	173.83	45.02	.....	263.62	131.81	57.00	.....	.....
(b) Shut-off valve		0.58	.....	.....	.....	0.14	12.37	24.53	24.64	.....	.....	.....
(c) Turbine gates or needle nozzle		0.93	.....	16.00	.....	4.23	21.15	9.33	25.82	.....	.....	.....
(d) Guide bearings or main bearings		.....	.....	.....	.....	.....	.....	6.55	3.28	.....	.....	.....
(e) Thrust bearing		.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
(f) Governor and governor system		15.33	28.53	13.10	27.27	21.06	6.50	2.47	7.73	.....	.....	.....
(g) Pressure regulator or deflectors		27.06	19.70	131.55	9.50	46.95	4.63	.....	4.63	.....	.....	.....
(h) Draft tube		10.15	27.15	2.50	17.00	14.20	.....	.....	.....	.....	.....	.....
(i) Lubrication system		.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
(j) Vibration		.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
(k) Seal rings		.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
(l) Inspection		62.55	140.95	84.67	45.99	83.54	9.46	66.51	42.71	7.00	1.00	.....
(m) General overhauling and replacement		.....	677.88	.....	153.75	207.91	.....	.....	.....	.....	.....	.....
(n) Other causes		.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
(o) Total Water-Wheel		**122.43**	**894.63**	**247.82**	**427.34**	**423.05**	**54.11**	**373.01**	**240.62**	**64.00**	**1.00**	**0.00**
15. Generator and Appurtenances,												
(a) Vibration		1.83	.....	.....	11.25	3.27	.....	.....	.....	.....	.....	.....
(b) Lubrication or oil leakage		.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
(c) Rotor or field		101.23	73.43	42.50	110.18	81.84	6.45	6.56	9.73	.....	.....	.....
(d) Armature iron or windings		13.23	.....	.....	.....	3.31	.....	.....	.....	6.00	.....	.....
(e) Exciter and rheostats		.....	0.17	0.75	2.50	0.86	.....	.....	.....	.....	.....	.....
(f) Ventilation system		.....	.....	8.00	.....	2.00	.....	.....	.....	.....	.....	.....
(g) Cleaning		117.97	44.85	.....	.....	40.70	12.35	.....	12.35	.....	11.00	.....
(h) Inspection		30.98	11.80	138.95	.....	45.43	.....	.....	.....	.....	8.00	2.00
(i) Other causes		.....	.....	.....	11.50	2.88	19.65	105.31a	72.30	.....	.....	.....
(j) Total Generator		**265.24**	**130.25**	**190.25**	**135.43**	**180.29**	**38.45**	**111.87**	**94.38**	**6.00**	**19.00**	**2.00**
16. Total All Causes—(13+14+15)		**390.62**	**1,024.88**	**438.02**	**562.77**	**604.08**	**92.56**	**484.88**	**335.00**	**143.00**	**177.00**	**2.00**
17. Number of Units Covered		**3**	**3**	**3**	**3**	**3**	**2**	**2**	**2**	**1**	**1**	**1**
18. Average Outage Hours Per Unit		**130.21**	**341.63**	**146.00**	**187.59**	**201.36**	**46.28**	**242.44**	**167.50**	**143.00**	**177.00**	**2.00**

b—Weighted.
a—Changes general cable.
b—Weighted average.
c—One unit only.
d—One unit 12 months, one un
e—Tunnel inspection.
f—New construction.
g—Rewiring swb'd.

	3							4									5			
b)	1924	1925	1926	1927	1928	1929	Avg.	1924	1925	1926	1927	1928	1929	Avg.	1926	1927	1928	1929	Avg.	1926
	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
9	.....	.....	.....	24.00	.....	.....	4.00	4.00	10.00	8.00	150.00	.....	9.00	30.17	.....	.....	.....	.....	.....	5.00
	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
9	0.00	0.00	0.00	24.00	0.00	0.00	4.00	4.00	10.00	8.00	150.00	0.00	9.00	30.17	0.00	0.00	0.00	14.00	3.50	1,256.00
	.....	.....	.....	.....	.....	.....	.....	3.00	.....	.....	.....	.....	.....	0.50	65.00	.....	.....	.....	16.25	.....
	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	8.00
	4.00	2.00	.....	6.00	.....	.....	2.00	3.00	6.00	5.00	.....	.....	1.00	2.50	.....	.....	.....	.....	.....	.....
	.....	.....	.....	.....	181.00	8.00	31.50	.....	.....	.....	.....	139.00	.....	23.17	.....	.....	.....	.....	.....	.....
9	1.00	4.00	.....	.....	1.00	1.00	1.17	.....	3.00	.....	.....	5.00	1.00	1.50	.....	.....	.....	5.00	1.25	.....
	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
5	10.00	.....	.....	.....	.....	1.00	1.83	.....	.....	.....	.....	.....	.....	.....	.....	.....	86.00	7.00	23.25	.....
	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
0	2.00	.....	10.00	.....	.....	.....	2.00	.....	.....	9.00	.....	.....	.....	1.50	16.00	.....	3.00	1.00	5.00	.....
5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
9	17.00	6.00	10.00	6.00	182.00	10.00	38.50	6.00	9.00	14.00	0.00	144.00	2.00	29.17	81.00	0.00	89.00	13.00	45.75	8.00
	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	.....	3.00	145.00	230.00	83.00	1.00	77.00	.....	.....	224.00	238.00	102.00	.....	94.00	.....	.....	.....	.....	.....	386.00
6	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1.00	0.17	.....	.....	.....	.....	.....	.....
4	1.00	23.00	9.00	1.00	.....	1.00	5.83	2.00	1.00	.....	.....	.....	.....	0.50	.....	.....	.....	.....	.....	13.00
	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	31.00	34.00	13.00	3.00	.....	4.00	14.17	12.00	16.00	3.00	.....	.....	4.00	5.83	.....	.....	.....	.....	.....	.....
3	31.00	30.00	11.00	.....	.....	4.00	12.67	12.00	12.00	3.00	.....	.....	3.00	5.00	.....	.....	.....	.....	.....	.....
5	.....	1.00	.....	.....	.....	.....	0.17	.....	.....	.....	.....	30.00	.....	5.00	.....	.....	.....	1.00	0.25	.....
8	63.00	91.00	178.00	234.00	83.00	10.00	109.84	26.00	29.00	230.00	238.00	132.00	8.00	110.50	0.00	0.00	0.00	1.00	0.25	399.00
6	80.00	97.00	188.00	264.00	265.00	20.00	152.33	36.00	48.00	252.00	388.00	276.00	19.00	169.83	81.00	0.00	89.00	28.00	49.50	1,663.00
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	3
8	80.00	97.00	188.00	264.00	265.00	20.00	132.33	36.00	48.00	252.00	388.00	276.00	19.00	169.83	40.50	0.00	45.00	14.00	24.75	554.33

of Unit.
ng Construction.
f outage not given.
y Tests.

i—All inspections and overhauling during scheduled idle hours.
j—Rewinding Gen. Damaged March 12, 1928.
k—Gen. Switch.
*—Scroll Case.
/—Demolished March 12, 1928.

			33					34 (No report 1927)					35A					35B		
24	1925	1926	1927	1928	1929	Avg.	1925	1926	1928	1929	Avg.	1926	1927	1928	1929	Avg.	1926	1927	1928
..	.....	.....	.....	.....	1,230.00	205.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
00	157.00	.....	117.00	84.00	11.00	73.67	206.00	.....	30.00	.....	7.50	.....	.....	.....	.....	.....	.....	.....	17.00	746.00
..	.....	.....	.....	.....	800.00	133.33	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
00	157.00	.....	117.00	84.00	2,041.00	412.00	206.00	.....	30.00	8.00	61.00	2.67	0.00	0.00	143.00	36.42	1.33	17.00	746.00
00	.....	.....	.....	.....	135.00	32.00	.....	.....	.....	.....	.....	37.33	.....	.....	320.00	89.33	18.67	387.00	70.00
..	.....	.....	.....	.....	.....	.....	.....	53.00	.....	.....	13.25	.....	.....	.....	.....	.....	.....	.....	.....
..	.....	.....	12.00	.....	69.00	13.50	70.50	66.00	25.00	.....	40.38	50.00	.....	95.00	19.00	41.00	25.00	5.00	8.00
..	.....	.....	.....	.....	.....	.....	149.50	.....	100.00	8.00	64.38	.....	.....	146.00	.....	36.50	.....	.....	.....
..	.....	.....	.....	.....	.....	.....	.....	43.00	50.00	1.00	23.50	.....	.....	.....	4.00	1.00	.....	.....	.....
..	.....	.....	.....	.....	.....	.....	100.50	54.00	.....	10.00	41.12	.....	.....	.....	.....	.....	.....	.....	.....
..	.....	.....	.....	.....	.....	.....	.....	.....	130.00	9.00	34.75	.....	.....	.....	.....	.....	.....	.....	.....
..	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
00	1.00	.....	.....	.....	1.00	1.50	18.50	20.00	.....	.....	9.62	13.33	3.00	10.00	.....	6.58	6.67	6.00	16.00
..	.....	.....	.....	.....	83.00	13.83	.....	.....	600.00	140.00	185.00	29.33	900.00	168.00	.....	274.33	14.67	331.00	.....
..	.....	.....	.....	.....	.....	.....	19.50	.....	.....	.....	4.88	.....	.....	.....	.....	.....	.....	.....	.....
00	1.00	0.00	12.00	0.00	288.00	60.83	358.50	236.00	905.00	168.00	416.88	130.00	903.00	419.00	343.00	448.74	65.00	729.00	94.00
..	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
..	.....	.....	.....	.....	.....	.....	.....	40.00	.....	3.00	10.75	.....	.....	.....	.....	.....	.....	.....	.....
..	.....	.....	.....	.....	.....	.....	27.00	333.00	300.00	62.00	180.50	.....	18.00	.....	.....	4.50	.....	.....	.....
00	.....	.....	.....	.....	.....	1.00	.....	.....	500.00	.....	125.00	.....	1,090.00	.....	1,250.00	585.00	.....	.....	.....
..	.....	.....	.....	.....	.....	.....	2.00	15.00	76.00	10.00	25.75	226.00	15.00	.....	.....	60.25	113.00	.....	.....
..	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
..	11.00	.....	.....	.....	2.00	2.17	10.00	60.00	50.00	.....	30.00	29.33	.....	.....	.....	7.33	14.67	.....	.....
..	8.00	2.00	.....	.....	.....	1.67	30.50	32.00	22.00	.....	21.12	2.67	.....	.....	.....	0.67	1.33	.....	.....
..	.....	.....	.....	22.00	4.00	4.33	.....	.....	50.00	.....	12.50	.....	.....	60.00	.....	15.00	.....	.....	18.00
00	19.00	2.00	0.00	22.00	6.00	9.17	69.50	480.00	998.00	75.00	405.62	258.00	1,123.00	60.00	1,250.00	672.75	129.00	0.00	18.00
00	177.00	2.00	129.00	106.00	2,335.00	482.00	634.00	716.00	1,933.00	251.00	883.50	391.00	2,026.00	479.00	1,736.00	1,157.91	195.00	746.00	858.00
	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	1	1	1
00	177.00	2.00	129.00	106.00	2,335.00	482.00	317.00	358.00	967.00	125.00	441.75	195.00	1,013.00	240.00	868.00	578.96	195.00	746.00	858.00

it 12 months, one unit 9 months.
inspection.
nstruction.
ng swb'd.

h—Changes for efficiency tests.
i—Efficiency tests.
j—Completing construction.
k—Changes to increase efficiency.
*—All inspections and overhauling during scheduled idle hours.

				5						6						7							
927	1928	1929	Avg.	1926	1927	1928	1929	Avg.	1926	1927	1928	1929	Avg.	1924	1925	1926	1927	1928	1929	Avg.	1924	1925
...	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	17.00	26.00	10.50	19.00	8.00	1.80	13.72	.....	.....
..00	.....	9.00	30.17	.....	.....	.....	.....	.....	5.00	.....	.....	198.00	50.75	.....	.....	.....	.....	.....	.....	.....	.....	.....
...	.....	.....	.....	.....	.....	.....	14.00	3.50	1,251.00a	.....	.....	.....	312.75	.....	13.00	.....	.....	.....	.....	2.17	.....	.....
..00	0.00	9.00	30.17	0.00	0.00	0.00	14.00	3.50	1,256.00	0.00	0.00	198.00	363.50	17.00	39.00	10.50	19.00	8.00	1.80	15.89	0.00	0.00
...	.....	.....	0.50	65.00	.....	.....	.....	16.25	.....	.....	.....	.....	.....	659.00	.....	241.00	.....	.....	.....	150.00	.....	.....
...	.....	.....	.....	.....	.....	.....	.....	.....	8.00	5.00	11.00	5.00	7.25	.....	.....	.....	.....	.....	.....	1.42	.....	.....
...	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	24.00	6.00	.....	8.50	.....	.....	.....	.....	1.42	.....	.....
...	.....	1.00	2.50	.....	.....	.....	.....	.....	.....	8.00	.....	.....	2.00	98.00	312.00	.....	1.00	157.00	336.00	150.67	2.00	16.00
...	139.00	.....	23.17	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	120.00	.....	.....	58.00	101.00	46.50	.....	.....
...	5.00	1.00	1.50	.....	.....	.....	5.00	1.25	.....	3.00	15.00	.....	4.50	1.00	75.25	32.75	.....	.....	1.50	18.42	0.20	.....
...	.....	.....	.....	.....	.....	.....	.....	.....	.....	118.00	696.00	.....	203.50	32.00	10.50	.....	4.00	.....	28.00	12.43	.....	.....
...	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	12.00	.....	.....	.....	.....	.....	2.00	.....	2.50
...	.....	.....	.....	.....	.....	86.00	7.00	23.25	.....	.....	17.00	3.00	5.00	35.00	7.00	.....	13.00	6.00	4.80	10.97	.....	4.00
...	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
...	.....	.....	.....	.....	.....	.....	.....	.....	.....	600.00	.....	.....	150.00	.....	73.50	.....	.....	.....	.....	12.25	.....	.....
...	.....	.....	1.50	16.00	.....	3.00	1.00	5.00	.....	.....	3.00	.....	0.75	7.00	.....	.....	8.00	.....	2.00	2.83	.....	.....
...	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	8.00	.....	.....	1.33	.....	.....
...	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	10.00	34.00	240.00c	.....	.....	.....	47.33	.....	600.00
..00	144.00	2.00	29.17	81.00	0.00	89.00	13.00	45.75	8.00	734.00	724.00	32.00	379.00	854.00	640.75	513.75	34.00	221.00	473.30	456.15	2.20	622.50
...	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
..00	102.00	.....	94.00	.....	.....	.....	.....	.....	386.00	.....	.....	2.00	97.00	.....	.....	.....	.....	.....	.....	.....	.....	.....
...	.....	1.00	0.17	.....	.....	.....	.....	.....	.....	40.00	.....	23.00	13.75	.....	148.00	.....	.....	.....	.....	24.66	.....	.....
...	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	72.00	.....	18.00	.....	.....	.....	.....	.....	.....	.....	.....	.....
...	.....	.....	0.50	.....	.....	.....	.....	.....	13.00	.....	.....	.....	2.25	.....	11.00	.....	.....	.....	.....	1.83	.....	.....
...	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	6.00	.....	.....	.....	.....	.....	1.00	.....	.....
...	.....	4.00	5.83	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	150.00	242.70	65.45	.....	.....
...	.....	3.00	5.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
...	30.00	.....	5.00	.....	.....	.....	1.00	0.25	.....	.....	.....	.....	.....	.....	.....	.....	7.00	20.00	397.80	70.80	.....	9.50
..00	132.00	8.00	110.50	0.00	0.00	0.00	1.00	0.25	399.00	40.00	72.00	25.00	134.00	6.00	159.00	0.00	7.00	170.00	640.50	163.74	0.00	9.50
..00	276.00	19.00	169.83	81.00	0.00	89.00	28.00	49.50	1,663.00	774.00	814.00	255.00	876.50	877.00	838.75	524.25	60.00	399.00	1,115.60	635.75	2.20	632.00
	1	1	1	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	1	1
..00	276.00	19.00	169.83	40.50	0.00	45.00	14.00	24.75	554.33	258.00	271.00	85.00	292.17	292.33	279.58	174.75	20.00	133.00	371.90	211.92	2.20	632.00

ring scheduled idle hours.
12, 1928.

			35A					35B					35C			36A (No Report 1927)						36
Avg.	1926	1927	1928	1929	Avg.	1926	1927	1928	1929	Avg.	1928 (6 mos.)	1929	Avg.(b)	1925	1926	1928	1929	Avg.	1925	1926	1927
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
7.50	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
51.50	.....	.....	.....	.....	.....	.....	17.00	746.00	.....	190.75	.....	72.00	36.00	.....	889.50	.....	8.00	224.37	.....	445.35	32.00
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
2.00	2.67	.....	.....	143.00	36.42	1.33	.....	.....	.....	0.33	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
61.00	2.67	0.00	0.00	143.00	36.42	1.33	17.00	746.00	0.00	191.08	0.00	72.00	36.00	0.00	889.50	0.00	8.00	224.37	0.00	445.35	32.00
.....	37.33	.....	.....	320.00	89.33	18.67	387.00	70.00	740.00	303.92	.....	.....	.....	1.86	.....	520.00	331.00	213.22	0.94	.....	.....
13.25	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.81	1.94	.....	.....	0.69	0.41	0.98	150.00
40.38	50.00	.....	95.00	19.00	41.00	25.00	5.00	8.00	2.00	10.00	20.00	24.00	32.00	30.74	20.44	23.00	49.00	30.80	15.39	10.23	5.00
64.38	.....	.....	146.00	.....	36.50	.....	.....	.....	.....	.....	.....	.....	.....	9.19	.....	.....	.....	2.30	4.59	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
23.50	.....	.....	.....	4.00	1.00	.....	.....	.....	.....	.....	62.00	160.00	142.00	81.40	2.19	.....	12.00	23.90	40.78	1.09	10.00
41.12	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	10.00	5.00	18.10	13.64	8.00	34.00	18.44	9.07	6.81	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
34.75	.....	.....	.....	.....	.....	.....	.....	.....	2.00	0.50	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
9.62	13.33	3.00	10.00	.....	6.58	6.67	6.00	16.00	3.00	7.92	.....	.....	.....	.....	17.14	4.00	36.00	14.28	.....	8.56	.....
85.00	29.33	900.00	168.00	.....	274.33	14.67	331.00	.....	.....	86.42	.....	.....	.....	.....	296.50	.....	.....	74.12	.....	148.17	.....
4.88	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.95	.....	.....	.....	0.23	0.47	.....	.....
16.88	130.00	903.00	419.00	343.00	448.74	65.00	729.00	94.00	747.00	408.76	82.00	194.00	179.00	143.05	351.86	555.00	462.00	377.98	71.65	175.74	165.00
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
10.75	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
80.50	.....	18.00	.....	.....	4.50	.....	.....	.....	.....	.....	12.00	.....	12.00	1.13	0.42	5.00	.....	1.64	0.54	0.21	.....
25.00	.....	1,090.00	.....	1,250.00	585.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
25.75	226.00	15.00	.....	.....	60.25	113.00	.....	.....	.....	28.25	.....	.....	.....	5.44	.....	.....	.....	1.36	2.72	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
30.00	29.33	.....	.....	.....	7.33	14.67	.....	.....	.....	3.67	.....	.....	.....	.....	.....	40.00	126.00	41.50	.....	.....	.....
21.12	2.67	.....	.....	.....	0.67	1.33	.....	.....	.....	0.33	.....	.....	.....	.....	.....	.....	48.00	12.00	.....	.....	.....
12.50	.....	.....	60.00	.....	15.00	.....	.....	18.00	23.00	10.25	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
05.62	258.00	1,123.00	60.00	1,250.00	672.75	129.00	0.00	18.00	23.00	42.50	12.00	0.00	12.00	6.57	0.42	45.00	174.00	56.50	3.26	0.21	0.00
83.50	391.00	2,026.00	479.00	1,736.00	1,157.91	195.00	746.00	858.00	770.00	642.34	94.00	266.00	227.00	149.62	1,241.78	600.00	644.00	658.85	74.91	621.30	197.00
2	2	2	2	2	2	1	1	1	1	1	1	1	1	2	2	2	2	2	1	1	1
41.75	195.00	1,013.00	240.00	868.00	578.96	195.00	746.00	858.00	770.00	642.34	94.00	266.00	227.00	74.81	620.89	300.00	322.00	329.42	74.91	621.30	197.00

during scheduled idle hours.

	8							9 (No Report 1925)						10A							10B
	1924	1925	1926	1927	1928	1929	Avg.	1924	1926	1927	1928	1929	Avg.	1924	1925	1926	1927	1928	1929	Avg.	1929 W (7 mos.) (
	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	30.00	.....	.....	5.00	.....
	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....	.....	.....	32.00	.....	29.00	14.00	.....	15.00	391.90	.....	.....	.....	.....	.....	65.31	9.00
	.....	.....	.....	.....	.....	.....	.....	24.00	.....	.....	.....	.....	4.80	.....	.....	.....	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....	.....	.....	240.00	.....	.....	.....	.....	48.00	23.77	.....	.....	.....	208.00	.....	38.63	.....
	0.00	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**296.00**	**0.00**	**29.00**	**14.00**	**0.00**	**67.80**	**415.67**	**0.00**	**0.00**	**30.00**	**208.00**	**0.00**	**108.94**	**9.00**
	.....	.....	.....	.....	.....	.....	.....	688.50	.....	97.00	108.00	899.00	358.50	.....	.....	.....	.....	.....	.....	.....	3.00
	.....	.....	.....	.....	.....	.....	.....	124.90	4.47	40.00	.....	212.00	76.27	164.42	.....	.....	.....	.....	50.00	35.77	.....
	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	25.00	94.00	23.80	.....	.....	6.05	.....	.....	.....	1.01	.....
	2.00	16.00	.....	23.00	.....	.....	6.83	613.10	13.65	12.00	43.00	5.00	137.35	.....	.....	4.70	45.00	.....	.....	8.28	.....
	.....	.....	.....	24.00	.....	.....	4.00	.....	.....	.....	.....	35.00	7.00	44.73	.....	7.35	25.00	.....	.....	12.85	.....
	0.20	.....	3.25	2.00	.....	.....	0.91	1.30	.....	15.00	18.00	.....	6.86	.....	.....	2.47	.....	7.00	.....	1.58	9.00
	.....	.....	.....	1.00	3.00	.....	0.67	.....	.....	.....	.....	4.00	0.80	.....	37.30	.....	.....	.....	.....	6.22	.....
	.....	2.50	.....	20.00	.....	.....	3.68	36.10	.....	16.00	2.00	.....	10.82	373.05	31.60	1.00	.....	.....	.....	67.61	.....
	.....	4.00	.....	2.00	.....	.....	1.00	506.00	12.15	.....	.....	.....	103.63	.....	.....	.....	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	27.88	.....	.....	4.00	5.31	.....
	.....	.....	.....	58.00	.....	.....	9.66	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	9.00
	.....	.....	1.00	.....	.....	.....	0.17	45.40	.....	72.00	15.00	16.00	29.68	.....	4.60	.....	2.00	.....	13.00	3.27	9.00
	.....	.....	.....	.....	.....	.....	.....	.....	688.48	.....	.....	53.00	148.30	.....	.....	542.98	.....	.....	.....	90.50	.....
	.....	600.00	.....	.....	196.00	.....	132.66	604.80	.....	.....	18.00	.....	124.56	.....	135.80	.....	15.00e	.....	.....	25.14	6.00
	2.20	**622.50**	**4.25**	**130.00**	**199.00**	**0.00**	**159.66**	**2,620.10**	**718.75**	**252.00**	**229.00**	**1,318.00**	**1,027.57**	**582.20**	**209.30**	**592.43**	**87.00**	**7.00**	**67.00**	**257.47**	**36.00**
	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	82.00	16.40	.....	.....	.....	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....	.....	.....	615.20	.....	34.00	.....	5.00	130.84	.....	.....	.....	4.00	.....	.....	0.66	.....
	.....	.....	6.50	.....	.....	.....	1.08	6.60	.....	.....	224.00	2,319.00d	509.92	.....	.....	.....	.....	8.00	1.33	2.00	
	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1,337.00	.....	267.40	.....	.....	.....	.....	2.00	0.33	.....	
	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4.00	.....	0.80	.....	5.70	1.67	.....	7.00	.....	2.40	.....
	.....	.....	.....	.....	.....	.....	.....	.....	2.73	.....	.....	1.00	0.75	.....	.....	.....	.....	.....	.....	.....	.....
	.....	.....	.....	.....	1.00	.....	0.17	1,001.00	.....	65.00	75.00	250.00	278.20	.....	.....	.....	30.00	15.00	56.00	16.83	.....
	.....	.....	.....	.....	.....	.....	.....	.....	.....	25.00	20.00	.....	9.00	.....	.....	.....	.....	6.00	6.00	2.00	11.00
	.....	9.50	.....	2.00	10.00	.....	3.58	48.00	.....	.....	59.00	6.00	22.60	.....	.....	.....	.....	.....	250.00e	41.67	149.00f
	0.00	**9.50**	**6.50**	**2.00**	**11.00**	**0.00**	**4.83**	**1,670.80**	**2.73**	**124.00**	**1,719.00**	**2,663.00**	**1,235.91**	**0.00**	**5.70**	**1.67**	**34.00**	**28.00**	**322.00**	**65.22**	**162.00**
	2.20	**632.00**	**10.75**	**132.00**	**210.00**	**0.00**	**164.49**	**4,586.90**	**721.48**	**405.00**	**1,962.00**	**3,981.00**	**2,331.28**	**997.87**	**215.00**	**594.10**	**151.00**	**243.00**	**389.00**	**431.65**	**207.00**
	1	**1**	**1**	**1**	**1**	**1**	**1**	**3**	**3**	**3**	**3**	**3**	**3**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**
	2.20	**632.00**	**10.75**	**132.00**	**210.00**	**0.00**	**164.49**	**1,528.97**	**240.49**	**135.00**	**654.00**	**1,327.00**	**777.10**	**997.87**	**215.00**	**594.10**	**151.00**	**243.00**	**389.00**	**431.65**	**207.00**

	36B						36C						37A (No Report 1927)							37B		
5	1926	1927	1928	1929	Avg.	1925 (7 mos.)	1926	1927	1928	1929	Avg.(b)	1924	1925	1926	1928	1929	Avg.	1924(c)	1925(d)	1926	1927	1928
..	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	11.03	.....	.....	2.21	.....	.....	11.03	31.00	.....
.	445.35	32.00	.....	.....	95.47	.....	74.38	.....	.....	.....	14.86	20.70	.....	.....	.....	.....	4.14	515.00	.....	.....	.....	5.00
.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	8.10	.....	.....	.....	.....	1.62	9.00	.....	.....	.....	.....
..	.....	.....	.....	.....	.....	14.38	.....	.....	.....	.....	4.93	.....	43.47	.....	.....	.....	8.69	.....	3.95	.....	30.00e	.....
00	**445.35**	**32.00**	**0.00**	**0.00**	**95.47**	**14.38**	**74.38**	**0.00**	**0.00**	**0.00**	**19.79**	**28.80**	**43.47**	**11.03**	**0.00**	**0.00**	**16.66**	**524.00**	**3.95**	**11.03**	**61.00**	**5.00**
94	.....	.....	.....	.....	0.20	.....	3.42	58.00	37.00	.....	19.68	.....	.....	.....	712.00	184.00	179.20	.....	.....	.....	.....	.....
41	0.98	150.00	.....	.....	30.28	.....	139.35	170.00	8.00	.....	63.47	.....	3.00	18.72	10.00	.....	6.34	.....	.....	14.23	.....	23.00
39	10.23	5.00	8.00	16.00	10.92	13.68	3.50	18.00	.....	12.00	11.39	.....	38.27	17.92	50.00	40.00	29.24	.....	58.88	48.73	20.00	18.00
59	.....	.....	.....	.....	0.92	1.87	6.67	.....	.....	.....	1.98	16.80	.....	.....	.....	.....	3.36	1.10	.....	.....	.....	.....
78	1.09	10.00	.....	.....	10.37	0.18	1.50	10.00	.....	11.00	4.56	7.00	9.48	5.25	2.00	64.00	17.55	0.80	23.43	.....	18.00	24.00
07	6.81	.....	.....	8.00	4.78	.....	.....	7.00	.....	.....	1.40	.....	4.40	.....	.....	.....	0.89	.....	1.98	.....	7.00	14.00
..	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
..	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
..	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
..	8.56	.....	21.00	11.00	8.11	18.15	6.78	.....	16.00	5.00	11.78	143.10	48.92	.....	33.00	38.00	52.60	68.00	52.53	.....	10.00	25.00
.	148.17	.....	.....	.....	29.63	.....	14.22	.....	.....	.....	2.84	.....	.....	.....	.....	.....	.....	.....	.....	.....	217.00	71.00
47	.....	.....	.....	.....	0.09	.....	4.32	.....	.....	.....	0.86	6.70	.....	47.42	43.00	79.00f	35.22	.....	4.50	26.17	5.00	52.00
65	**175.74**	**165.00**	**29.00**	**35.00**	**95.30**	**33.88**	**179.76**	**263.00**	**61.00**	**28.00**	**117.96**	**173.60**	**104.07**	**89.31**	**850.00**	**405.00**	**324.40**	**69.90**	**141.32**	**89.13**	**277.00**	**227.00**
..	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
..	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
54	0.21	.....	8.00	.....	1.75	.....	.....	.....	.....	6.00	1.20	1.20	.....	150.00	57.00	8.00	43.24	63.60	.....	20.00	.....	3.00
..	.....	.....	.....	.....	.....	.....	.....	.....	.....	158.00	31.60	576.40	34.25	.....	.....	254.00	172.93	.....	32.25	.....	.....	.....
72	.....	.....	.....	.....	0.54	0.75	.....	.....	.....	.....	0.25	.....	1.90	.....	.....	.....	0.38	.....	1.90	.....	.....	.....
..	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
..	.....	.....	80.00	50.00	26.00	.....	.....	.....	.....	80.00	56.00	27.20	2.80	.....	20.00	140.00	32.56	.....	.....	85.75	.....	78.00
..	.....	.....	60.00	24.00	16.80	.....	.....	.....	.....	60.00	4.00	12.80	214.50	.....	13.00	60.00	65.50	66.40	9.58	30.00	.....	67.00
..	.....	.....	.....	4.00	0.80	.....	.....	.....	.....	.....	.....	.....	0.60	.....	26.00	33.00g	11.92	.....	4.50	.....	.....	62.00
26	**0.21**	**0.00**	**148.00**	**78.00**	**45.89**	**0.75**	**0.00**	**0.00**	**140.00**	**224.00**	**73.05**	**795.50**	**36.15**	**190.00**	**116.00**	**495.00**	**326.53**	**130.00**	**48.23**	**135.75**	**0.00**	**210.00**
91	**621.30**	**197.00**	**177.00**	**113.00**	**236.66**	**49.01**	**254.14**	**263.00**	**201.00**	**252.00**	**210.80**	**997.90**	**183.69**	**290.34**	**966.00**	**900.00**	**667.59**	**723.90**	**193.50**	**235.91**	**338.00**	**442.00**
	1	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**2**	**2**	**2**	**2**	**2**	**2**	**1**	**2**	**2**	**2**	**2**
91	**621.30**	**197.00**	**177.00**	**113.00**	**236.66**	**49.01**	**254.14**	**263.00**	**201.00**	**252.00**	**210.80**	**498.95**	**91.85**	**145.17**	**483.00**	**450.00**	**333.80**	**723.90**	**96.75**	**117.96**	**169.00**	**221.00**

	10A						10B			11							12A				
Avg.	1924	1925	1926	1927	1928	1929	Avg.	1929 Weighted (7 mos.)	(12 mos.)	1924	1925	1926	1927	1928	1929	Avg.	1926	1927	1928	1929	Avg
.....	.....	.....	.....	30.00	.....	.....	5.00	.....	.....	15.52	.....	.....	.....	.....	.....	2.59	.....	.....	.....	.....	...
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...
15.00	391.90	.....	.....	.....	.....	.....	65.31	9.00	15.43	.....	.....	9.65	23.00	79.00	27.00	23.11	7.73	.....	.....	.....	1.9
4.80	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1.01	.....	.....	.....	0.2
48.00	23.77	.....	.....	.....	208.00	.....	38.63	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...
67.80	**415.67**	**0.00**	**0.00**	**30.00**	**208.00**	**0.00**	**108.94**	**9.00**	**15.43**	**15.52**	**0.00**	**9.65**	**23.00**	**79.00**	**27.00**	**25.70**	**8.74**	**0.00**	**0.00**	**0.00**	**2.1**
358.50	.....	.....	.....	.....	.....	.....	.....	3.00	5.14	.....	4.93	.....	93.00	.....	.....	16.32	11.98	.....	.....	.....	3.0
76.27	164.42	.....	.....	.....	.....	50.00	35.77	.....	.....	298.00	.....	192.43	.....	.....	.....	115.07	11.71	.....	.....	41.62	13.3
23.80	.....	.....	6.05	.....	.....	.....	1.01	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	10.48	.....	2.0
137.35	.....	.....	4.70	45.00	.....	.....	8.28	.....	.....	.....	.....	20.72	25.00	.....	.....	7.62	24.65	3.37	8.47	67.71	26.0
7.00	44.73	.....	7.35	25.00	.....	.....	12.85	.....	.....	29.00	.....	.....	65.00	383.00	.....	79.50	.....	2.58	.....	953.69	239.0
6.86	.....	.....	2.47	.....	7.00	.....	1.58	9.00	15.43	.....	1.68	8.40	21.00	.....	1.00	5.35	20.55	31.43	17.33	35.92	36.3
0.80	.....	37.30	.....	.....	.....	.....	6.22	.....	.....	.....	61.22	.....	.....	.....	.....	10.20	5.83	3.50	9.20	.....	4.0
10.82	373.05	31.60	1.00	.....	.....	.....	67.61	.....	.....	.....	.....	.....	90.00	.....	.....	15.00	.....	.....	.....	.....	...
103.63	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1.45	.....	.....	.....	.....	0.24	223.62	77.28	27.90	67.85	99.1
.....	.....	.....	27.88	.....	.....	4.00	5.31	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...
.....	.....	.....	.....	.....	.....	.....	.....	9.00	15.43	.....	.....	.....	.....	.....	.....	.....	6.23	3.80	.....	.....	2.5
29.68	.....	4.60	.....	2.00	.....	13.00	3.27	9.00	15.43	27.00	.....	.....	.....	2.00	.....	4.83	.....	1.72	8.71	8.00	4.6
148.30	.....	.....	542.98	.....	.....	.....	90.50	.....	.....	.....	.....	17.37	.....	.....	.....	2.90	2,245.50	230.77	2,075.12	.....	1,137.9
124.56	.....	135.80	.....	15.00*	.....	.....	25.14	6.00	10.29	3,764.00g	.....	.....	.....	.....	.....	627.33	.....	0.33	h237.13	.....	59.3
1,027.57	**582.20**	**209.30**	**592.43**	**87.00**	**7.00**	**67.00**	**257.47**	**36.00**	**61.72**	**4,318.00**	**69.28**	**238.92**	**294.00**	**385.00**	**1.00**	**884.30**	**2,550.07**	**354.78**	**2,394.34**	**1,174.79**	**1,618.3**
16.40	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	...
130.84	.....	.....	.....	4.00	.....	.....	0.66	.....	.....	.....	.....	.....	.....	60.00	.....	10.00	.....	.....	.....	.....	...
509.92	.....	.....	.....	.....	.....	8.00	1.33	2.00	3.43	36.00	.....	56.68	.....	.....	.....	15.45	35.68	9.83	.....	.....	11.3
267.40	.....	.....	.....	.....	.....	2.00	0.33	.....	.....	.....	.....	.....	.....	.....	.....	.....	15.55	.....	.....	18.00	8.3
0.80	.....	5.70	1.67	.....	7.00	.....	2.40	.....	.....	.....	.....	.....	.....	.....	.....	.....	3.92	16.23	25.53	4.37	12.2
0.75	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	6.87	1.27	.....	4.70	3.3
278.20	.....	.....	.....	30.00	15.00	56.00	16.83	.....	.....	.....	.....	.....	94.00	.....	.....	15.67	.....	.....	6.52	.....	1.9
9.00	.....	.....	.....	.....	6.00	6.00	2.00	11.00	18.86	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4.07	1.0
22.60	.....	.....	.....	.....	.....	250.00e	41.67	149.00f	255.43	.....	1.77	.....	.....	.....	.....	0.30	.....	.....	.....	2.00	0.5
1,235.91	**0.00**	**5.70**	**1.67**	**34.00**	**28.00**	**322.00**	**65.22**	**162.00**	**277.72**	**36.00**	**1.77**	**56.68**	**94.00**	**60.00**	**0.00**	**41.41**	**62.02**	**27.33**	**32.05**	**33.14**	**38.0**
2,331.28	**997.87**	**215.00**	**594.10**	**151.00**	**243.00**	**389.00**	**431.65**	**207.00**	**354.87**	**4,369.52**	**71.05**	**305.25**	**411.00**	**524.00**	**28.00**	**954.45**	**2,620.83**	**382.11**	**2,427.30**	**1,207.93**	**1,659.3**
3	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**4**	**4**	**4**	**4**	**4**
777.10	**997.87**	**215.00**	**594.10**	**151.00**	**243.00**	**389.00**	**431.65**	**207.00**	**354.87**	**2,184.76**	**35.53**	**152.63**	**205.50**	**262.00**	**14.00**	**475.73**	**655.21**	**95.53**	**606.60**	**302.00**	**414.**

	37A (No Report 1927)						37B					37C	37D	38 (No Report 1927)					39			
25	1926	1928	1929	Avg.	1924(c)	1925(d)	1926	1927	1928	1929	Avg.(b)	1929	1929	1925	1926	1928	1929	Avg.	1926	1927	1928	1929
..	11.03	.....	.....	2.21	.....	.....	11.03	31.00	.....	.....	7.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
..	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
..	.....	.....	.....	4.14	515.00	.....	.....	.....	5.00	.....	172.50	11.00	11.00	876.30	699.68	.....	.....	394.00	.....	.....	.....	.....
..	.....	.....	.....	1.62	9.00	.....	.....	.....	.....	.....	3.00	.....	.....	.....	28.40	.....	.....	7.10	.....	67.23	.....	.....
47	.....	.....	.....	8.69	.....	3.95	.....	30.00e	.....	.....	5.75	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
47	**11.03**	**0.00**	**0.00**	**16.66**	**524.00**	**3.95**	**11.03**	**61.00**	**5.00**	**0.00**	**188.25**	**11.00**	**11.00**	**876.30**	**728.08**	**0.00**	**0.00**	**401.10**	**0.00**	**67.23**	**0.00**	**0.00**
..	.....	712.00	184.00	179.20	.....	.....	.....	.....	.....	.....	.....	1,256.00h	.....	644.30	19.30	.....	.....	165.90	.....	.....	.....	.....
00	18.72	10.00	.....	6.34	.....	.....	14.23	.....	23.00	.....	6.21	.....	74.00	.....	.....	.....	.....	.....	.....	.....	.....	.....
27	17.92	50.00	40.00	29.24	.....	58.88	48.73	20.00	18.00	24.00	29.67	9.00	36.00	.....	0.20	186.00	.....	46.55	.....	.....	.....	.....
..	.....	.....	.....	3.36	1.10	.....	.....	.....	.....	.....	0.37	44.00	.....	.....	.....	.....	.....	.....	.....	.....	0.20	.....
..	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
48	5.25	2.00	64.00	17.55	0.80	23.43	.....	18.00	24.00	40.00	18.40	26.00	23.00	.....	7.33	2.00	20.00	7.33	.....	2.18	.....	2.20
40	.....	.....	.....	0.89	.....	1.98	.....	7.00	14.00	20.00	7.21	.....	6.00	20.80	.....	.....	.....	5.20	.....	.....	.....	.....
..	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
..	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	14.00	.....	.....	.....	.....	.....	.....	.....	.....	.....
..	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
92	.....	33.00	38.00	52.60	68.00	52.53	.....	10.00	25.00	36.00	44.51	15.00	15.00	.....	.....	12.00	.....	3.00	.....	.....	1.00	1.00
..	.....	.....	.....	.....	.....	.....	.....	217.00	71.00	.....	48.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
..	47.42	43.00	79.00f	35.22	.....	4.50	26.17	5.00	52.00	40.00f	21.38	68.00i	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
07	89.31	850.00	405.00	324.40	69.90	141.32	89.13	277.00	227.00	160.00	175.75	1,418.00	168.00	665.10	26.83	200.00	20.00	227.98	0.00	2.18	1.20	3.20
..	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
..	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.	150.00	57.00	8.00	43.24	63.60	.....	20.00	.....	3.00	8.00	26.37	3.00	4.00	0.20	99.52	.....	.....	24.93	.....	.....	.....	.....
25	.....	.....	254.00	172.93	.....	32.25	.....	.....	.....	.....	6.14	.....	.....	.....	.....	368.00	.....	92.00	.....	.....	.....	59.90
00	.....	.....	.....	0.38	.....	1.90	.....	.....	.....	.....	0.36	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
..	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.	.....	20.00	140.00	32.56	.....	.....	85.75	.....	78.00	117.00	46.79	.....	.....	0.80	.....	4.00	.....	1.20	.....	.....	.....	.....
.	40.00	13.00	60.00	65.50	66.40	9.58	30.00	.....	67.00	54.00	49.12	5.00	5.00	2.20	.....	.....	.....	0.55	.....	.....	.....	.....
.	.....	26.00	33.00g	11.92	.....	4.50	.....	.....	62.00	3.00	11.69	66.00j	80.00c	46.00	0.43	.....	.....	54.11	.....	.....	.....	.....
15	190.00	116.00	495.00	326.53	130.00	48.23	135.75	0.00	210.00	182.00	140.47	74.00	89.00	219.20	99.95	372.00	0.00	172.79	0.00	0.00	0.00	59.90
69	290.34	966.00	900.00	667.59	723.90	193.50	235.91	338.00	442.00	342.00	504.47	1,503.00	268.00	1,760.60	854.86	572.00	20.00	801.87	.....	69.41	1.20	63.10
	2	**2**	**2**	**2**	**1**	**2**	**2**	**2**	**2**	**2**	**2**	**1**	**1**	**4**	**4**	**4**	**4**	**4**	**1**	**1**	**1**	**1**
85	145.17	483.00	450.00	333.80	723.90	96.75	117.96	169.00	221.00	171.00	252.23	1.503.00	268.00	440.15	213.72	143.00	5.00	200.47	0.00	69.41	1.20	63.10

12B					13						14f (No Report 1928)				15	Plant Index Number
																Year
1929	Avg.	1926	1927	1928	1929	Avg.	1927 (6 mos.)	1928	1929	Avg. b	1927	.....	1929	Avg. (1 Year)	1929	Item Cause
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	13. General Hydraulic Causes,
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a) Ice or trash
.....	1.83	.....	13.32	.....	.....	3.33	.....	.....	1,160.00	580.00	.....	.....	.....	.....	5.00	(b) Floods
.....	0.25	8.00	.....	.....	.....	2.00	65.00	.....	.....	65.00	.....	.....	.....	.....	.....	(c) Penstock or canal
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(d) Headgates or intake
0.00	**2.18**	**8.00**	**13.32**	**0.00**	**0.00**	**5.33**	**65.00**	**0.00**	**1,160.00**	**645.00**	**0.00**	.....	**0.00**	.....	**5.00**	(e) Other general hydraulic
																(f) Total General Hydraulic
.....	3.00	3.57	.....	.....	.....	0.89	.....	.....	.....	.....	.....	.....	.....	.....	.....	14. Water-Wheels and Auxiliaries,
41.62	13.33	3.18	7.07	.....	6.75	4.25	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a) Runner
.....	2.62	8.08	5.80	14.42	6.00	8.58	.....	4.00	15.00	9.50	.....	.....	.....	.....	.....	(b) Shut-off valve
67.71	26.05	1.88	2.03	2.55	21.50	6.99	.....	3.00	.....	1.50	.....	.....	.....	.....	632.00	(c) Turbine gates or needle nozzle
953.69	239.06	.....	.....	.....	.....	.....	.....	5.00	.....	2.50	.....	.....	.....	.....	.....	(d) Guide bearings or main bearings
35.92	36.31	5.13	10.90	1.08	7.93	6.26	.....	65.00	.....	32.50	.....	.....	.....	.....	10.00	(e) Thrust bearing
.....	4.63	.....	.....	.....	.....	.....	889.00	1,173.00	.....	1,475.50	.....	.....	.....	.....	.....	(f) Governor and governor system
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(g) Pressure regulator or deflectors
67.85	99.16	2.70	34.65	5.88	14.93	14.54	.....	.....	2.00	1.00	.....	.....	.....	.....	.....	(h) Draft tube
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(i) Lubrication system
.....	2.51	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(j) Vibration
8.00	4.61	.....	.....	.....	.....	.....	.....	36.00	4.00	20.00	.....	.....	.....	.....	3.00	(k) Seal rings
.....	1,137.80	.....	.....	.....	.....	.....	.....	.....	380.00	190.00	.....	.....	.....	.....	.....	(l) Inspection
.....	59.36	.....	.....	h185.13	.....	46.28	.....	.....	.....	.....	.....	.....	.....	.....	.....	(m) General overhauling and replacement
1,174.79	**1,618.50**	**24.54**	**60.45**	**209.06**	**57.11**	**87.79**	**889.00**	**1,286.00**	**401.00**	**1,732.50**	**0.00**	.....	**0.00**	.....	**645.00**	(n) Other causes
																(o) Total Water-Wheel
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	15. Generator and Appurtenances,
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a) Vibration
.....	11.38	2.25	15.52	.....	.....	4.44	.....	80.00	.....	40.00	.....	.....	.....	.....	1.00	(b) Lubrication or oil leakage
18.00	8.39	.....	.....	.....	.....	.....	.....	6.00	.....	3.00	.....	.....	582.00	582.00	.....	(c) Rotor or field
4.37	12.51	14.40	15.17	.....	16.51	11.52	.....	.....	.....	.....	.....	.....	.....	.....	.....	(d) Armature iron or windings
4.70	3.21	.....	.....	.....	.....	.....	32.00	.....	.....	32.00	.....	.....	.....	.....	.....	(e) Exciter and rheostats
.....	1.63	.....	9.42	.....	4.00	3.36	.....	.....	.....	.....	.....	.....	.....	.....	.....	(f) Ventilation system
4.07	1.02	8.13	.....	.....	.....	2.03	.....	.....	3.00	1.50	.....	.....	.....	.....	.....	(g) Cleaning
2.00	0.50	.....	.....	8.70	.....	2.18	.....	.....	.....	.....	.....	.....	.....	.....	48.00k	(h) Inspection
33.14	**38.64**	**24.78**	**40.11**	**8.70**	**20.51**	**23.52**	**32.00**	**86.00**	**3.00**	**76.50**	**0.00**	.....	**582.00**	**582.00**	**49.00**	(i) Other causes
1,207.93	**1,659.32**	**57.32**	**113.88**	**217.76**	**77.62**	**116.64**	**986.00**	**1,372.00**	**1,564.00**	**2,454.00**	**0.00**	.....	**582.00**	**582.00**	**699.00**	(j) Total Generator
4	**4**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	.....	**2**	**2**	**1**	16. Total All Causes—(13+14+15)
302.00	**414.83**	**28.66**	**56.94**	**108.88**	**38.81**	**58.32**	**493.00**	**686.00**	**782.00**	**1,227.00**	**0.00i**	.....	**291.00**	**291.00**	**699.00**	17. Number of Units Covered
																18. Average Outage Hours Per Unit

39				40			41A (No Report 1928)			41B	42	Plant Index Number
												Year
1928	1929	Avg.	1927 (10 mos.)	1928	1929	Avg. (b)	1927	1929	Avg.	1929	1929	Item Cause
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	13. General Hydraulic Causes,
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a) Ice or trash
.....	.....	.....	.....	.....	15.70	5.23	.....	.....	.....	.....	16.60	(b) Floods
.....	.....	16.81	.....	.....	.....	.....	.....	.....	.....	.....	.....	(c) Penstock or canal
.....	.....	.....	.....	6.00	0.80	2.27	.....	.....	.....	.....	.....	(d) Headgates or intake
0.00	**0.00**	**16.81**	**0.00**	**6.00**	**16.50**	**7.50**	.....	.....	.....	.....	**16.60**	(e) Other general hydraulic
												(f) Total General Hydraulic
.....	.....	.....	.....	8.00	.....	2.67	.....	.....	.....	.....	132.00	14. Water-Wheels and Auxiliaries,
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a) Runner
.....	.....	.....	11.00	12.00	.....	8.40	.....	.....	.....	.....	160.30	(b) Shut-off valve
0.20	.....	0.05	.....	.....	.....	.....	.....	.....	.....	.....	28.90	(c) Turbine gates or needle nozzle
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(d) Guide bearings or main bearings
.....	2.20	1.10	.....	.....	1.00	0.33	.....	.....	.....	.....	43.50	(e) Thrust bearing
.....	.....	.....	15.00	.....	.....	6.00	.....	.....	.....	.....	.....	(f) Governor and governor system
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(g) Pressure regulator or deflectors
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(h) Draft tube
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(i) Lubrication system
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(j) Vibration
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(k) Seal rings
1.00	1.00	0.50	.....	.....	2.00	0.67	.....	.....	.....	.....	140.90	(l) Inspection
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(m) General overhauling and replacement
1.20	**3.20**	**1.65**	**26.00**	**101.00**	**321.50**	**151.23**	.....	.....	.....	.....	**541.60**	(n) Other causes
												(o) Total Water-Wheel
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	15. Generator and Appurtenances,
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(a) Vibration
.....	.....	.....	9.00	.....	1.50	4.10	.....	.....	.....	.....	801.50	(b) Lubrication or oil leakage
.....	59.90	14.97	440.00	.....	.....	176.00	.....	.....	.....	.....	.....	(c) Rotor or field
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(d) Armature iron or windings
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(e) Exciter and rheostats
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(f) Ventilation system
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	160.30	(g) Cleaning
.....	.....	.....	396.00	51.00	.....	175.40	.....	.....	.....	.....	302.00	(h) Inspection
0.00	**59.90**	**14.97**	**845.00**	**51.00**	**1.50**	**355.50**	.....	.....	.....	.....	**1,263.80**	(i) Other causes
1.20	**63.10**	**33.43**	**871.00**	**158.00**	**339.50**	**514.23**	.....	.....	.....	.....	**1,822.00**	(j) Total Generator
1	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**		**1**	**4**	16. Total All Causes—(13+14+15)
1.20	**63.10**	**33.43**	**871.00**	**158.00**	**339.50**	**514.23**	*	*		*	**455.50**	17. Number of Units Covered
												18. Average Outage Hours Per Unit

TABLE VII-A—Analysis of Hydro-Electric Plant Outage Hours

Item Cause / Year	Vertical Turbines — Hours							Impulse Water-Wheels — Hours							Horizontal Turbines — Hours							All Hydro-Electric Units — Hours						
	1924	1925	1926	1927	1928	1929	Total	1924	1925	1926	1927	1928	1929	Total	1924	1925	1926	1927	1928	1929	Total	1924	1925	1926	1927	1928	1929	Total
13. General Hydraulic Causes:																												
(a) Ice or Trash	32.52	26.00	10.50	49.00	8.00	1.80	127.82	0.00	0.00	22.06	31.00	0.00	1,230.00	1,283.06	0.00	0.00	0.00	6.25	0.00	0.00	6.25	32.52	26.00	32.56	86.25	8.00	1,231.80	1,417.13
(b) Floods	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	30.00	0.00	30.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	30.00	0.00	30.00
(c) Penstock or canal	427.90	10.00	30.38	239.32	123.78	1,414.43	2,245.81	608.70	1,239.30	2,111.86	166.00	835.00	145.30	5,106.16	9.00	15.00	0.00	60.90	5.00	1,435.60	1,525.50	1,045.60	1,264.30	2,142.24	466.22	963.78	2,995.33	8,877.47
(d) Headgates or intake	24.00	13.00	9.01	130.00	0.00	0.00	176.01	17.10	0.00	28.40	67.23	0.00	800.00	912.73	0.00	0.00	4.25	7.75	0.00	0.00	12.00	41.10	13.00	41.66	204.98	0.00	800.00	1,100.74
(e) Other general hydraulic	263.77	55.75	1,251.00	0.00	208.00	14.00	1,792.52	0.00	72.63	4.00	30.00	6.00	151.80	264.43	0.00	0.00	38.00	8.28	0.00	2.50	48.78	263.77	128.38	1,293.00	38.28	214.00	168.30	2,105.73
(f) Total General Hydraulic	748.19	104.75	1,300.89	418.32	339.78	1,430.23	4,342.16	625.80	1,311.93	2,166.32	294.23	871.00	2,327.10	7,596.38	9.00	15.00	42.25	83.18	5.00	1,438.10	1,592.53	1,382.99	1,431.68	3,509.46	795.73	1,215.78	5,195.43	13,531.07
14. Water Wheels and Auxiliaries:																												
(a) Runner	1,350.50	3,164.82	722.22	190.00	108.00	1,277.74	6,813.28	57.00	647.10	84.52	445.40	1,347.00	3,535.45	6,116.52	2.00	0.00	86.20	134.00	0.00	0.00	222.20	1,409.50	3,811.92	892.97	769.42	1,455.00	4,813.19	13,152.00
(b) Shut-off valve	787.32	0.00	219.79	52.07	11.00	315.37	1,385.55	0.00	4.22	228.80	320.00	65.74	98.53	717.29	0.00	0.00	28.58	1.89	0.00	0.00	30.47	787.32	4.22	477.17	373.96	76.74	413.90	2,133.31
(c) Turbine gates or Needle Nozzle	0.00	8.50	14.13	5.80	58.32	139.00	225.75	0.00	245.64	242.95	73.20	523.30	469.63	1,554.72	0.00	0.00	0.00	0.00	0.00	2.50	2.50	0.00	254.14	257.08	79.00	581.62	611.13	1,782.97
(d) Guide Bearings or Main Bearings	720.10	336.00	90.03	125.40	214.02	1,063.21	2,548.76	17.00	166.49	6.67	0.00	246.20	87.45	524.71	22.00	9.00	6.90	7.37	7.45	255.30	308.02	760.00	511.49	103.60	132.77	467.67	1,405.96	3,381.49
(e) Thrust Bearing	73.73	120.00	7.35	116.58	766.00	1,097.69	2,181.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	23.00	0.00	0.00	23.00	73.73	120.00	7.35	139.58	766.00	1,097.69	2,204.35
(f) Governor and governor system	3.50	83.93	95.22	141.28	168.91	89.18	582.02	7.80	158.75	75.69	68.71	228.10	437.44	976.49	0.00	15.30	17.25	5.90	0.00	12.00	50.45	11.30	257.98	188.16	215.89	397.01	538.62	1,608.96
(g) Pressure regulator or deflectors	32.00	109.02	5.83	1,904.50	1,881.20	32.00	3,964.55	0.00	155.13	101.51	51.70	162.81	97.50	568.65	1.00	0.00	10.70	0.00	4.85	1,081.20	1,097.75	33.00	264.15	118.04	1,956.20	2,048.86	1,210.70	5,630.95
(h) Draft tube	421.15	34.10	1.00	126.00	2.00	0.00	584.25	0.00	0.00	10.15	27.15	2.50	17.00	56.80	0.00	0.00	1.25	0.00	0.00	0.00	1.25	421.15	34.10	12.40	153.15	4.50	17.00	642.30
(i) Lubrication system	551.00	12.45	238.47	126.93	143.78	106.98	1,178.61	0.00	0.00	0.00	0.00	130.00	25.00	155.00	0.00	0.00	0.00	1.50	6.35	0.00	7.85	551.00	12.45	238.47	128.43	279.13	131.98	1,341.46
(j) Vibration	0.00	0.00	32.28	0.00	0.00	4.00	36.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.00	0.00	0.00	0.00	3.00	0.00	0.00	35.28	0.00	0.00	4.00	39.28
(k) Seal rings	0.00	73.50	6.23	661.80	13.63	15.43	770.59	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	173.00	13.47	45.22	14.90	246.59	0.00	73.50	179.23	675.27	58.85	30.33	1,017.18
(l) Inspection	81.40	24.81	36.00	90.72	81.91	72.63	387.47	218.10	159.59	135.03	159.95	241.59	416.40	1,330.66	3.00	0.00	24.00	0.00	1.40	4.20	32.60	302.50	184.40	195.03	250.67	324.90	493.23	1,750.73
(m) General overhauling and replacement	0.00	0.00	3,494.33	238.77	2,075.12	748.30	6,556.52	0.00	0.00	502.89	2,125.88	839.00	376.75	3,844.52	0.00	0.00	1,755.00	0.00	244.00	178.00	2,177.00	0.00	0.00	5,752.22	2,364.65	3,158.12	1,303.05	12,578.04
(n) Other causes	4,378.80	769.80	240.00	15.33	636.26	10.29	6,050.48	6.70	26.06	77.91	5.00	176.00	541.50	833.17	0.00	7.57	0.00	87.73	1.33	0.00	96.63	4,385.50	803.43	317.91	108.06	813.59	551.79	6,980.28
(o) Total Water Wheel	8,399.50	4,736.93	5,202.88	3,795.18	6,159.15	4,971.82	33,265.46	307.50	1,562.96	1,466.15	3,277.01	3,962.24	6,102.65	16,678.52	28.00	31.87	2,105.88	274.86	310.60	1,542.10	4,299.31	8,735.00	6,331.78	8,774.91	7,347.05	10,431.99	12,622.57	54,243.30
15. Generator and Appurtenances:																												
(a) Vibration	0.00	0.00	0.00	0.00	0.00	82.00	82.00	0.00	0.00	1.83	0.00	0.00	11.25	13.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.83	0.00	0.00	93.25	95.08
(b) Lubrication or oil leakage	615.20	3.00	755.00	506.00	245.00	8.00	2,132.20	0.00	0.00	40.00	0.00	0.00	3.00	43.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	615.20	3.00	795.00	506.00	245.00	11.00	2,175.20
(c) Rotor or field	42.60	148.00	101.11	65.35	316.12	2,355.43	3,028.61	64.80	28.87	704.38	102.13	452.40	1,010.74	2,363.42	3.00	0.00	12.20	6.00	0.00	0.40	21.60	110.40	176.87	817.69	173.58	768.52	3,366.57	5,413.63
(d) Armature iron or windings	0.00	0.00	15.55	0.00	1,415.00	602.00	2,032.55	582.40	71.10	13.23	1,618.00	868.00	1,721.90	4,874.67	0.00	1,344.42	0.00	0.00	486.02	0.00	1,830.44	582.40	1,415.52	28.78	1,618.00	2,769.02	2,323.90	8,737.62
(e) Exciter and rheostats	3.00	40.70	43.82	40.45	37.81	24.98	190.76	0.00	15.52	354.00	15.17	76.75	12.50	473.94	0.00	10.00	3.16	4.38	1.27	2.10	20.91	3.00	66.22	400.98	60.00	115.83	39.58	685.61
(f) Ventilation system	6.00	0.00	9.60	65.27	0.00	5.70	86.57	0.00	0.00	0.00	0.00	8.00	0.00	8.00	0.00	17.00	0.00	74.32	0.00	0.00	91.32	6.00	17.00	9.60	139.59	8.00	5.70	185.89
(g) Cleaning	1,044.00	50.00	16.00	201.42	255.52	560.70	2,127.64	2.80	21.80	307.72	44.85	376.70	651.30	1,405.17	2.00	2.00	6.00	0.00	7.00	0.00	17.00	1,048.80	73.80	329.72	246.27	639.22	1,212.00	3,549.81
(h) Inspection	43.00	42.00	26.13	25.0	26.86	50.33	213.32	280.90	51.65	138.98	11.80	360.95	502.00	1,346.28	0.00	2.00	0.00	0.00	0.03	0.20	2.23	323.90	95.65	165.11	36.80	387.84	552.53	1,561.83
(i) Other causes	48.00	12.27	0.00	9.00	127.70	974.43	1,171.40	0.60	221.14	0.43	475.20	328.30	329.81	1,355.48	2.00	0.00	0.00	6.57	0.00	3.20	11.77	50.60	233.41	0.43	490.77	456.00	1,307.44	2,538.65
(j) Total generator	1,801.80	295.97	967.21	912.49	2,424.01	4,663.57	11,065.05	931.50	410.08	1,560.57	2,267.25	2,471.10	4,242.50	11,883.00	7.00	1,375.42	21.36	91.27	494.32	5.90	1,995.27	2,740.30	2,081.47	2,549.14	3,271.01	5,389.43	8,911.97	24,943.32
16. Total All Causes: (13—14—15)	10,949.49	5,137.65	7,470.98	5,125.99	8,922.94	11,065.62	48,672.67	1,864.80	3,284.99	5,193.04	5,838.49	7,304.34	12,672.25	36,157.91	44.00	1,422.29	2,169.49	449.31	809.92	2,992.10	7,887.11	12,858.29	9,844.93	14,833.51	11,413.79	17,037.20	26,729.97	92,717.69
17. Number of Units Covered	12	11	25	29	29	33	.....	4	15	22	14	26	32	.....	1	3	4	4	4	4	.....	17	29	51	47	59	69	.....
18. Average Outage Hours Per Unit	912.46	467.06	298.84	176.76	307.69	335.32	.....	466.20	219.00	236.05	417.04	280.94	396.00	.....	44.00	474.10	542.37	112.33	202.48	748.02	.....	756.37	339.48	290.85	242.85	288.77	387.39	.....

TABLE VII-B—Analysis of Hydro-Electric Plant Outage Hours

	Vertical Turbines							Horizontal Turbines							Impulse Water-Wheels							All Hydro-Electric Units						
	Percent							Percent							Percen							Percent						
Year	1924	1925	1926	1927	1928	1929	Avg.	1924	1925	1926	1927	1928	1929	Avg.	1924	1925	1926	1927	1928	1929	Avg.	1924	1925	1926	1927	1928	1929	Avg.
Item Cause																												
13. General Hydraulic Causes:																												
(a) Ice or Trash	0.28	0.51	0.14	0.96	0.09	0.02	0.26	0.00	0.00	0.00	1.39	0.00	0.00	0.08	0.00	0.00	0.42	0.53	0.00	9.70	3.56	0.25	0.26	0.22	0.76	0.05	4.61	1.53
(b) Floods	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.41	0.00	0.08	0.00	0.00	0.00	0.00	0.18	0.00	0.03
(c) Penstock or canal	3.91	0.20	0.41	4.66	1.39	12.78	4.62	20.45	1.05	0.00	13.55	0.62	47.98	19.34	32.64	37.73	40.67	2.84	11.43	1.15	14.13	8.13	12.85	14.44	4.07	5.65	11.21	9.57
(d) Headgates or intake	0.22	0.25	0.12	2.54	0.00	0.00	0.36	0.00	0.00	0.20	1.72	0.00	0.00	0.15	0.92	0.00	0.55	1.15	0.00	6.31	2.51	0.32	0.13	0.28	1.80	0.00	2.99	1.19
(e) Other general hydraulic	2.41	1.08	16.74	0.00	2.33	0.13	3.68	0.00	0.00	1.75	1.84	0.00	0.08	0.62	0.00	2.21	0.08	0.51	0.08	1.20	0.73	2.05	1.30	8.72	0.34	1.26	0.63	2.27
(f) Total General Hydraulic	6.83	2.04	17.41	8.16	3.81	12.93	8.92	20.45	1.05	1.95	18.51	0.62	48.06	20.19	33.56	39.94	41.72	5.03	11.92	18.36	21.01	10.75	14.54	23.66	6.97	7.14	19.44	14.59
14. Water Wheels and Auxiliaries:																												
(a) Runner	12.33	61.60	9.67	3.71	1.21	11.55	14.00	4.55	0.00	3.97	29.83	0.00	0.00	2.82	3.06	19.69	1.63	7.63	18.45	27.90	16.92	10.96	38.72	6.02	6.74	8.54	18.00	14.17
(b) Shut-off valve	7.19	0.00	2.94	1.02	0.12	2.85	2.85	0.00	0.00	1.32	0.42	0.00	0.00	0.39	0.00	0.13	4.41	5.48	0.90	0.78	1.98	6.12	0.04	3.22	3.28	0.45	1.55	2.30
(c) Turbine gates or Needle Nozzle	0.00	0.16	0.19	0.11	0.65	1.26	0.46	0.00	0.00	0.00	0.00	0.00	0.08	0.03	0.00	7.48	4.68	1.25	7.16	3.71	4.30	0.00	2.58	1.73	0.69	3.41	2.29	1.92
(d) Guide Bearings or Main Bearings	6.58	6.54	1.21	2.45	2.40	9.61	5.24	50.00	0.63	0.32	1.64	0.92	8.53	3.90	0.96	5.07	0.13	0.00	3.37	0.69	1.45	5.91	5.20	0.70	1.16	2.74	5.26	3.65
(e) Thrust Bearing	0.67	2.34	0.10	2.27	8.58	9.91	4.48	0.00	0.00	0.00	5.12	0.00	0.00	0.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.57	1.22	0.05	1.22	4.50	4.11	2.38
(f) Governor and governor system	0.03	1.63	1.27	2.76	1.89	0.81	1.20	0.00	1.08	0.80	1.31	0.00	0.40	0.64	0.42	4.83	1.46	1.18	3.12	3.45	2.70	0.09	2.62	1.27	1.89	2.33	2.02	1.74
(g) Pressure regulator or deflectors	0.29	2.12	0.08	37.15	21.08	0.29	8.14	2.27	0.00	0.49	0.00	0.60	36.14	13.92	0.00	4.73	1.95	0.89	2.23	0.77	1.57	0.26	2.68	0.80	17.14	12.02	4.53	6.07
(h) Draft tube	3.85	0.66	0.01	2.46	0.02	0.00	1.20	0.00	0.00	0.06	0.00	0.00	0.00	0.02	0.00	0.00	0.20	0.47	0.03	0.13	0.16	3.28	0.36	0.08	1.34	0.03	0.06	0.69
(i) Lubrication system	5.03	0.24	3.19	2.48	1.60	0.97	2.42	0.00	0.00	0.00	0.33	0.78	0.00	0.10	0.00	0.00	0.00	0.00	1.78	0.20	0.43	4.29	0.13	1.61	1.13	1.64	0.49	1.45
(j) Vibration	0.00	0.00	0.43	0.00	0.00	0.04	0.07	0.00	0.00	0.14	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.24	0.00	0.00	0.01	0.04
(k) Seal rings	0.00	1.43	0.08	12.91	0.15	0.14	1.58	0.00	0.00	7.97	3.00	5.58	0.50	3.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.75	1.21	5.92	0.35	0.12	1.10
(l) Inspection	0.74	0.48	0.48	1.76	0.92	0.66	0.80	6.81	0.00	1.11	0.00	0.17	0.14	0.41	11.70	4.86	2.60	2.74	3.31	3 29	3.68	2.35	1.87	1.31	2.19	1.91	1.85	1.89
(m) General overhauling and replacement	0.00	0.00	46.77	4.66	23.26	6.76	13.47	0.00	0.00	80.89	0.00	30.14	5.95	27.60	0.00	0.00	9.67	36.41	11.49	2.97	10.63	0.00	0.00	38.78	20.72	18.53	4.87	13.57
(n) Other causes	39.99	14.98	3.21	0.30	7.13	0.08	12.43	0.00	0.53	0.00	19.53	0.16	0.00	1.23	0.36	0.79	1.50	0.09	2.41	4.27	2.30	34.11	8.16	2.14	0.95	4.78	2.06	7.53
(o) Total Water Wheel	76.71	92.20	69.64	74.04	69.02	44.93	68.34	63.63	2.24	97.07	61.18	38.35	51.74	54.51	16.50	47.58	28.23	56.14	54.25	48.16	46.12	67.94	64.32	59.16	64.37	61.23	47.22	58.60
15. Generator and Appurtenances:																												
(a) Vibration	0.00	0.00	0.00	0.00	0.00	0.74	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.09	0.04	0.00	0.00	0.01	0.00	0.00	0.35	0.10
(b) Lubrication or oil leakage	5.62	0.06	10.11	9.87	2.75	0.07	4.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.77	0.00	0.00	0.02	0.12	4.78	0.03	5.37	4.43	1.44	0.04	2.35
(c) Rotor or field	0.39	2.88	1.35	1.27	3.54	21.29	6.22	6.82	0.00	0.56	1.34	0.00	0.01	0.27	3.47	0.88	13.56	1.75	6.19	7.98	6.54	0.86	1.80	5.52	1.52	4.51	12.60	5.84
(d) Armature iron or windings	0.00	0.00	0.21	0.00	15.86	5.44	4.17	0.00	94.53	0.00	0.00	60.01	0.00	23.20	31.23	2.16	0.25	27.71	11.89	13.59	13.48	4.53	14.38	0.19	14.18	16.24	8.69	9.42
(e) Exciter and rheostats	0.03	0.79	0.59	0.79	0.42	0.23	0.39	0.00	0.70	0.14	0.97	0.16	0.07	0.27	0.00	0.47	6.82	0.26	1.05	0.10	1.31	0.02	0.67	2.70	0.53	0.68	0.15	0.74
(f) Ventilation system	0.06	0.00	0.13	1.27	0.00	0.05	0.18	0.00	1.20	0.00	16.54	0.00	0.00	1.16	0.00	0.00	0.00	0.00	0.11	0.00	0.02	0.05	0.17	0.06	1.22	0.05	0.02	0.20
(g) Cleaning	9.53	0.97	0.21	3.93	2.86	5.07	4.37	4.55	0.14	0.28	0.00	0.86	0.00	0.22	0.15	0.66	5.93	0.77	5.16	5.14	3.89	8.16	0.75	2.22	2.16	3.75	4.53	3.83
(h) Inspection	0.39	0.82	0.35	0.49	0.30	0.45	0.44	0.00	0.14	0.00	0.00	0.00	0.01	0.03	15.06	1.57	2.68	0.20	4.94	3.96	3.72	2.52	0.97	1.11	0.32	2.28	2.07	1.69
(i) Other causes	0.44	0.24	0.00	0.17	1.43	8.81	2.42	4.55	0.00	0.00	1.46	0.00	0.11	0.15	0.03	6.74	0.01	8.14	4.49	2.60	3.75	0.39	2.37	0.00	4.30	2.68	4.89	2.74
(j) Total generator	16.46	5.76	12.95	17.80	27.17	42.14	22.74	15.92	96.71	0.98	20.31	61.03	0.20	25.30	49.94	12.48	30.05	38.83	33.83	33.48	32.87	21.31	21.14	17.18	28.66	31.63	33.34	26.91
16. Total All Causes—(13+14+15)	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
17. Numberof Units Covered	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
18. Average Outage Hours Per Unit	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

TABLE VIII—Analysis of Hydro-electric Plant Outage Hours

	Vertical Turbines					Horizontal Turbines			Impulse Wheels	
	Pelton	Allis Chalmers	Wellman Seaver Morgan	I.P. Morris	S. Morgan Smith	Pelton	Allis Chalmers	Worthington	Pelton	Allis Chalmers
Number of Units	9	8	7	7	2	1	2	1	16	16
Average size of units	28,100	22,125	25,257	19,000	17,690	20,000	18,600	7,500	25,100	22,800
Total installed Hp.	250,300	177,000	176,800	133,000	35,380	20,000	37,200	7,500	401,500	364,500
Per cent of total installed Hp.	32.38	22.92	22.90	17.23	4.57	30.91	57.50	11.59	52.30	47.70
Average annual outage hours per unit	143.00	97.20	58.70	101.20	433.00	576.40	17.40	113.80	94.00	151.50
Per cent of total outage	31.80	19.20	10.11	17.49	21.40	79.50	4.82	15.68	38.30	61.70
14. Water Wheels and Auxiliaries										
(a) Runner	0.33	11.16	2.96	0.03	0.00	3.12	0.00	2.97	12.70	38.50
(b) Shut-off valve	1.48	0.00	0.63	1.02	0.00	0.00	0.00	1.06	3.86	1.03
(c) Turbine gates or needle nozzle	0.05	0.02	0.19	0.14	0.12	0.00	0.04	0.00	4.86	2.33
(d) Guide bearings or main bearings	15.72	1.45	1.24	0.45	0.02	0.00	3.85	0.24	0.80	2.04
(e) Thrust bearing	0.98	0.48	1.41	1.80	0.03	0.51	0.00	0.00	0.00	0.00
(f) Governor and governor system	0.85	0.46	0.12	0.34	0.40	0.00	0.45	0.00	4.96	1.99
(g) Pressure regulator or deflectors	1.80	0.12	0.00	0.18	18.20	24.85	0.01	0.62	0.50	1.48
(h) Draft tube	0.18	0.12	0.09	1.67	0.00	0.00	0.00	0.04	0.00	0.12
(i) Lubrication system	0.08	0.40	0.90	0.79	0.02	0.00	0.11	0.00	0.37	0.45
(j) Vibration	0.00	0.02	0.00	0.13	0.00	0.00	0.04	0.00	0.00	0.00
(k) Seal rings	1.61	0.37	0.00	0.01	0.00	0.37	0.10	7.72	0.00	0.00
(l) Inspection	0.57	0.20	0.33	0.11	0.26	0.55	0.10	0.05	3.00	2.31
(m) General overhauling and replacement	0.24	0.74	1.22	9.26	2.35	50.10	0.00	0.00	6.73	5.82
(n) Other causes	7.93	3.66	1.02	1.56	0.00	0.00	0.12	3.02	0.52	5.63
(o) Total water wheel	31.80	19.20	10.11	17.49	21.40	79.50	4.82	15.68	38.30	61.70

	Vertical Generators			Horizontal Generators		
	General Electric	Allis Chalmers	Westinghouse	General Electric	Westinghouse	Allis Chalmers
Number of units	20	6	7	24	11	1
Average size of units	18,025	20,533	20,143	15,760	22,100	15,000
Total installed Kva.	360,500	123,200	141,000	378,419	243,000	15,000
Per cent of total installed Kva.	57.72	19.70	22.58	59.46	38.18	2.36
Average annual outage hours per unit	497.90	9.90	64.90	55.00	77.70	12.00
Per cent of total outage	65.90	3.95	30.15	60.40	39.10	0.50
15. Generator and Appurtenances						
(a) Vibration	0.00	0.00	0.36	0.05	0.00	0.00
(b) Lubrication or oil leakage	13.85	0.00	2.90	0.26	0.00	0.00
(c) Rotor or field	1.67	0.62	12.61	15.50	2.09	0.50
(d) Armature iron or windings	19.85	0.00	6.00	21.10	18.90	0.00
(e) Exciter and rheostats	1.24	0.04	0.10	0.68	2.84	0.00
(f) Ventilation system	0.05	0.02	1.08	0.38	0.12	0.00
(g) Cleaning	3.10	1.45	6.20	5.68	3.39	0.00
(h) Inspection	2.84	0.00	0.30	5.75	3.71	0.00
(i) Other causes	23.30	1.82	0.60	11.00	8.05	0.00
(j) Total generator	65.90	3.95	30.15	60.40	39.10	0.50

TABLE IX—Index to Hydro-Electric Plants.

Index No.	Company	Plant	Waterwheel Manufacturer	Generator Manufacturer
		Vertical Turbines		
1	California Oregon Power Company	Copco No. 2	Allis-Chalmers	Westinghouse
2	California Oregon Power Company	Prospect No. 2	Pelton	General Electric
3	Pacific Gas & Electric Company	Hat Creek No. 1	Wellman-Seaver-Morgan	General Electric
4	Pacific Gas & Electric Company	Hat Creek No. 2	Wellman-Seaver-Morgan	General Electric
5	Pacific Gas & Electric Company	Pit River No. 1	Allis-Chalmers	Allis-Chalmers
6	Pacific Gas & Electric Company	Pit River No. 3	Pelton	General Electric
7	San Joaquin Light & Power Corp.	Kerckhoff	Allis-Chalmers	Allis-Chalmers
8	San Joaquin Light & Power Corp.	Kern Canyon	Allis-Chalmers	Allis-Chalmers
9	Southern California Edison Company	Big Creek No. 3	Wellman-Seaver-Morgan	Westinghouse
10A	Southern California Edison Company	Big Creek No. 8—Unit 1	I. P. Morris	General Electric
10B	Southern California Edison Company	Big Creek No. 8—Unit 2	Pelton	General Electric
11	Southern California Edison Company	Kern River No. 3	Pelton	General Electric
12A	Great Western Power Company	Big Bend—Units 1, 2, 3, 4	I. P. Morris	General Electric
12B	Great Western Power Company	Big Bend—Units 5 & 6	I. P. Morris	General Electric
13	Pacific Gas & Electric Company	Melones	S. Morgan Smith	Westinghouse
14	Bureau of Power & Light	San Francisquito No. 2	Wellman-Seaver-Morgan	General Electric
15	Pacific Gas & Electric Company	Spaulding No. 1	Pelton	General Electric
		Horizontal Turbines		
21	California Oregon Power Company	Copco No. 1	Allis-Chalmers	General Electric
22	Pacific Gas & Electric Company	Wise	Pelton	Westinghouse
23	Southern Sierras Power Company	Adams Main	Worthington	General Electric
		Impulse Waterwheels		
31	Great Western Power Company	Caribou	Allis-Chalmers	General Electric
32	Great Western Power Company	Feather River	Pelton	General Electric
33	Pacific Gas & Electric Company	Spring Gap	Pelton	General Electric
34	Pacific Gas & Electric Company	El Dorado	Allis-Chalmers	General Electric
35A	Pacific Gas & Electric Company	Drum—Units 1 & 2	Pelton	Westinghouse
35B	Pacific Gas & Electric Company	Drum—Unit 3	Pelton	Westinghouse
35C	Pacific Gas & Electric Company	Drum—Unit 4	Pelton	Allis-Chalmers
36A	Southern California Edison Company	Big Creek No. 1—Units 1 & 2	Allis-Chalmers	General Electric
36B	Southern California Edison Company	Big Creek No. 1—Unit 3	Allis-Chalmers	General Electric
36C	Southern California Edison Company	Big Creek No. 1—Unit 4	Pelton	Westinghouse
37A	Southern California Edison Company	Big Creek No. 2—Units 3 & 4	Allis-Chalmers	Westinghouse
37B	Southern California Edison Company	Big Creek No. 2—Units 5 & 6	Pelton	Westinghouse
37C	Southern California Edison Company	Big Creek No. 2A—Unit 1	Allis-Chalmers	Westinghouse
37D	Southern California Edison Company	Big Creek No. 2A—Unit 2	Pelton	Westinghouse
38	Southern California Edison Company	Kern River No. 1	Allis-Chalmers	General Electric
39	Southern Sierras Power Company	Poole	Pelton	General Electric
40	San Joaquin Light & Power Corp.	Balch	Allis-Chalmers	General Electric
41A	Bureau of Power & Light—Unit No. 4	San Francisquito No. 1	Pelton	Westinghouse
41B	Bureau of Power & Light—Unit No. 5	San Francisquito No. 1	Allis-Chalmers	Allis-Chalmers
42	Hetch Hetchy Water Supply	Moccasin	Pelton	General Electric

*Hydraulic Plant Operating Problems**

Due to the interest manifested last year in the report of the hydraulic plant operating problems committee, it was decided to continue the report and endeavor to bring out information which was omitted or briefly covered.

These problems and comments are submitted by superintendents, foremen and operators and are prompted by difficulties experienced in the actual operation of their respective plants.

The purpose of this report is to bring to the attention of power plant designers and builders the problems involved in hydraulic plant operation and to formulate recommendations for improvements in design, manufacture and construction to help prevent the occurrence of operating troubles.

Among the subjects covered are:
Storage Reservoirs.
Water Conduits.
Long Distant Water Level Gages.
Penstocks.
Turbines.
Draft Tubes.
Impulse Water Wheels.

Storage Reservoirs

TROUBLE was experienced with radial gates in high altitudes where the lake level varies considerably. Ice freezes on them and as the lake level rises the gates open. The frame work of the gates does not seem strong enough and if it was strengthened they would not perform the service for which they were installed.

Gates and their control should be located so that they will not be covered with snow or likely to be flooded by backwater when discharging into a snow blocked channel. Protection should be provided to keep ice from blocking the mechanism such as sleeves, over gate-stems and covers over gearing and oil holes.

Removing Flash Boards—

Proper means should be provided for removing flash boards such as an iron pin through each end to engage a forked hook. The board should not have an area over three or four square feet in order to be easily handled by one man and the slots should have plenty of clearance as only the bearing surface prevents leakage.

Remote Water Level Indicator—

One of our greatest problems is to acquire a remote water level indicator which will successfully indicate the depth of water in tenths of feet over a range from zero to two hundred feet.

Water Conduits

Trash on Racks—

Several companies report difficulties due to trash accumulating on racks. Various designs of self-cleaning racks have been installed but the desired satisfaction in operation has not been obtained.

It is desired that the power for operating the racks be supplied by the water in the canal, thus keeping the cost of operation low.

If a water wheel in the canal is used it should be arranged so that it can be raised or lowered according to the head in the canal.

As the trash drops off of the grids it should automatically be carried away or a space should be provided for at least a twelve-hour run.

Provision should be made for a safe method of stopping the rack when maintenance work is necessary. The grids should be assembled in small sections to facilitate their removal, which is necessary during the periods when ice and snow are floating.

Clearing Ice From Canal—

Crest type spillways, with long clear passageways, are well suited for sluicing snow and ice from a canal. The approach should avoid boils or eddy currents to use a minimum of water.

A rough granite surface is conducive to the formation of side and anchor ice and the hardest to clean. Abrupt angles should be avoided as ice forms first in agitated water. Smooth surfaces following flow lines give the least amount of trouble.

Trapped Air—

Trapped air in syphons, especially where a variable head is carried, will invariably start "pounding" unless the water level at the intake portal is held within certain limits by throttling the syphon outlet with flash-boards, radial gates or otherwise.

Sand in Penstocks—

Considerable trouble is experienced from sand and grit being carried into the penstocks where unlined tunnels and ditches are used.

Poor results are obtained from sand traps unless the velocity of the water is very low, as if the grit is in suspension it is carried over the barriers.

In designing a sand trap the width of the channel should be given proper consideration. A narrow channel flushes out rapidly and completely and with a wide channel the wastage of water alone is a large item.

Long Distant Water Level Gages

Induction Type—

Of the different kinds of long distant water level gages on the market, the position or induction type is apparently giving the most satisfactory service. More attention should be given to the location and type of control circuits, source of energy, insulation against freezing and adequate protection from lightning.

Protection for Pressure Tube—

Low temperature caused the pressure tube on a water level gage to split. To avoid this the copper tube was covered with a ¾-in. garden hose, using a water tight connection on the ends. This formed an air space around the tube and no further trouble from freezing was experienced.

Penstocks—Air Valves

Suggested Changes in Air Valve Construction—

A greater clearance between valve stems and their guide bushings is suggested.

A square section should be left on the end of the stem so that a wrench can be used for turning it. Shelters should be provided to prevent freezing. A reliable design places the air valve inside of a heated shelter providing air flaps to admit air if necessary.

Automatic combination air inlet and outlet valves of the simplex type are giving very satisfactory service but it is very essential that they be of sufficient capacity in the event that a serious break occurs in the line.

* Report of subcommittee on hydraulic plant operating problems, hydraulic power committee, Engineering Section. L. G. Roberts, chairman. H. W. Bertholas, C. L. Davis, R. B. Lawton, R. D. Likely, P. J. Ost, R. R. Robertson, C. P. Vetter.

Reducing Valves—

Considerable trouble is experienced with reducing valves for the camp water supply on high head penstocks, on account of the excessive wear of the different parts. In some instances surges were set up and there is also the hazard of the supply pipe breaking or wearing out, which would at least make it necessary to drain the penstock.

Camp water supplied from the afterbay, springs or a nearby creek, by means of a pump, is preferred because an economy is effected as the water used from the penstock of a high head plant represents a large amount of kilowatt-hours when a year's total is considered.

Grounded Control Circuit—

An 84-in. butterfly valve, located at one plant at the surge chamber intake, closed due to a grounded control circuit. The ground detector lamps on the station control battery were of sufficient capacity so that when the ground was established on the control circuit it completed the circuit through the trip solenoid, thereby closing the gate. At this time lamp-type ground detectors were used as is common in many plants.

The above hazard has been completely removed by replacing the lamp detector with the voltmeter type which takes less than 10 watts to energize it.

Turbines

Balance of Turbine Gates—

The proper balance of turbine gates as affecting operation merits consideration.

In full automatic plants it is generally agreed that the balance be such that the wickets would close in the event of oil failure on the governor.

In a plant with attendants in charge the problem changes; here the least wear and more satisfactory operation of the governor should be considered.

In a plant where the turbine gates balance at 70 or 80 per cent load, the turbines normally operating at less than 50 per cent load, the governor is working under a strain at all times, causing additional maintenance as well as difficult regulation.

The impression is received that the average turbine, when not specified otherwise, has its gates balanced at too high a percentage of the load. This point, however, should enter in the specifications of the turbine to operate under a certain head and under a certain condition. It is felt that insufficient attention is being paid to this point and the operator, therefore, suffers the disadvantage.

Adjustable Wearing Rings for Horizontal Units—

In horizontal units adjustable wearing rings on both sides of the runner would have many advantages and we wonder if this has been given the proper consideration. Thrust bearings should be supplied and so mounted as to take care of the maximum thrust which may be imposed upon them should the balance pressure fail to the extreme.

Small Pumps vs. Oil Rings—

We suggest that consideration be given to replacing the present oil rings with small pumps. Damage has resulted from oil ring failure and excessive leakage has been caused due to spray and vapor.

Vertical Turbines

Water in Oil Sump—

In lower guide bearings considerable trouble has developed due to water finding its way into the lower oil sump. There appears to be an opportunity for considerable improvement in the design at this point of a unit. The packing gland, lower guide and oil sump are so located that to repack the gland too much dismantling would be necessary and the outage hours would be increased. Improved operating conditions would result if the oiling system could be kept a separate unit and the oil sump removed from its present location.

Relief Valve Draft Tubes

Draft Tube Vibration—

Several companies report trouble from relief valve draft tube vibration. One draft tube was found in the afterbay and considerable damage resulted to the machinery foundation. The vibration can perhaps be eliminated only by the designers but we have found by experience that it can be reduced and maintenance costs lowered by welding the stubs on the tubes and concreting them in solidly.

Trouble at Certain Loads—

Vibration at certain turbine loads, caused apparently by the momentary breaking of the vacuum, is reported. There appears to be no relief except to regulate your load so as to keep off of the critical point. This can be done when there is an operator in the plant, but it is a serious condition in a full or partial automatic station.

Impulse Water Wheels

Welding Experiments—

Welding needles and nozzle tips with different metals, cast iron, bronze and steel cast, has been tried by one company. They report the most beneficial results have been obtained from the steel cast, it giving the desired strength and even wear as well as the durability. Experiments are being made to obtain a plating which will be applied to the finished surface of a hard metal.

Nozzle Tip Fractures—

Nozzle tip studs made of Tobin bronze fracture quite readily and are unreliable. Replacements are being made with steel called "Calumate" which has so far proven satisfactory. Eight threads per inch, rather than the standard thread, is recommended. In many instances stud material failure is caused by improper and excessive tightening and jamming the needles against the seats due to the adjustment of the limit switches.

Steel Cast Bucket—

The conventional steel cast bucket, used by all well-known manufacturers, on the whole gives very good service, depending upon the amount of grit in the water, size of unit, head, etc. The troubles experienced usually developed within a short period after the installation, generally in the form of checks and cracks which, after being properly welded, seemed to correct a condition of internal stresses which was created when the bucket was cast.

Very little difference is noted in the eastern and western steel-cast product, yet as a whole the eastern steel castings seem more free from sand holes.

Large Diameter Bucket Studs—

Bucket studs of large diameter proved to have an advantage over smaller ones. Past troubles have proven that it is imperative that all studs for large units should have a press fit in a true hole of from 25 to 40 tons.

Steel Lining Trouble—

Considerable trouble is experienced with the steel lining on the side walls of the wheel pits becoming loose due to a contact with the water expelled from the buckets, vibration and imperfect concrete backing. We found that the bedplates cast in the concrete became loose enough to allow leakage, due to expansion and contraction, vibration and perhaps faulty construction and installation.

As a remedy we would recommend a specially constructed

baffle, enclosing the spider and buckets, which might improve the efficiency as well as prevent any leakage.

Removal of Water Wheels—

We would also recommend the continuance of building the pit and wheel housing bedplates to allow the removal of the water wheels (as some recent manufacturers have done), avoiding costly dismantling when the occasion demands.

Oil and Water Lines in Power Houses—

It is suggested that the installation of oil and water lines in power houses be given consideration. A sufficient number of valves should be used and crossover pipes installed to permit sectionalizing. The pipe should be run in trenches or in the open where it can be easily replaced after a few years' service, which is necessary due to the accumulation of rust, barnacles, etc. If it is necessary to bury it in the concrete, a special metal, not influenced by rust and chemical action, should be used.

Facilitating Repairs—

Guard valves, next to the main gate, by-pass and in series with the blow-off valves on the main gates, would allow repairs without draining the penstock.

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*Use of Concrete in Hydraulic Structures**

This report consists of two parts: Part I, entitled "Effect of Powdered Admixtures on Concrete," and Part II, "Mixing and Placing Concrete for Concrete Bench Flumes."

In Part I is given a general description of the various forms of diatomaceous earth and volcanic ash, and their effect on workability, chemical reaction, strength and permeability is analyzed. It is intended in some future report to extend the investigation to other admixtures, both powdered and liquid, provided sufficient information of unbiased nature is available.

Owing to the controversial nature of the subject, care has been taken to use only data of unquestionable reliability and it has been attempted to present facts rather than final conclusions and recommendations. The hope is expressed that the member companies of the Pacific Coast Electrical Association will recognize the advantage of co-ordinating their researches on concrete, thus avoiding duplication of tests, and bringing their individual results to a comparable basis.

Part II gives, in words and pictures, the experiences of three member companies in constructing concrete bench flumes in different localities and under different circumstances. They represent actual solutions of actual problems, and are therefore thought to be of value to others in solving their individual problems along similar lines. This part of the report was compiled by H. K. Fox, H. Keesling, and K. A. Reeder.

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* Report of subcommittee on use of concrete in hydraulic structures, hydraulic power committee, Engineering Section. C. P. Vetter, chairman. W. Dreyer, H. K. Fox, H. Keesling, F. J. Mills, K. A. Reeder.

Part One—Effect of Powdered Admixtures on Concrete[1]

Introduction

THE report of the subcommittee for 1929 dealt with the various factors which influence concrete in hydraulic structures. It was pointed out that strength tests do not always give a true picture of the quality of the concrete or a reliable prediction of how it will perform the duties imposed upon it.

The report was in the form of a general outline of the subject, the intention being later to deal with the individual factors in more detail.

For 1930 it was decided to investigate the influence of powdered admixtures on concrete. The following subjects will be treated:

A. Description of the various forms of commercial admixtures in practical use.
B. Workability, a general discussion of this term and how it may be measured.
C. Effect of admixtures on workability.
D. Constitution and hydrolysis of Portland cement.
E. Effect of admixtures on the hydrolysis of cement.
F. Effect of admixtures on the compressive strength of concrete.
G. Effect of admixtures on the permeability of concrete.
H. Economic value of admixtures.

Diatomaceous Earth

By diatomaceous earth is understood the siliceous remains of diatoms, a genus of minute, flowerless aquatic plants of the order of algae. The diatoms live in salt, brackish, and fresh water. The minute organisms assimilate inorganic salts from

[1] Prepared by C. P. Vetter, W. Dreyer and F. J. Mills.

Fig. 1. Salt water diatoms from California. (Rock Products, March 16, 1929.)

their surroundings and form a skeleton structure of silica which serves as a support for the gelatinous mass of the living organisms. When the diatoms die they sink to the bottom together with other materials such as sand, clay or volcanic ash and form the deposits known as diatomaceous earth.

The diatoms are of numerous shapes, up to 15,000 distinct species having been recognized, and vary greatly with the locality where they are found. In the United States the greatest deposits are found in the Western states: Washington, Oregon, California and Nevada. These Western deposits are not all of the same character. Fig. 1 shows a specimen of diatomaceous earth from the California Coast; Fig. 2 a specimen from Nevada; and Fig. 3 a specimen from Washington. The diatoms from California and Washington are from organisms living in salt water, while the specimen from Nevada is a fresh water diatom.

This difference in the character of the deposit and the shape of the diatoms is claimed to have an important bearing on their influence on workability when the diatomaceous earth is used as admixtures for concrete. This is further discussed under "Influence on Workability."

The diatoms consist almost entirely of amorphous silica (SiO_2), a typical analysis of a California diatomaceous earth being given below:

	Moisture-free Basis Per Cent	Ignited Basis Per Cent
Silica (SiO_2)	81.57	86.16
Iron oxide (Fe_2O_3)	1.82	1.92
Alumina (Al_2O_3)	8.52	9.00
Titania (TiO_2)	0.36	0.38
Lime (CaO)	0.81	0.85
Magnesia (MgO)	1.09	1.15
Ignition loss	5.32	
Alkalies and undetermined	0.51	0.54

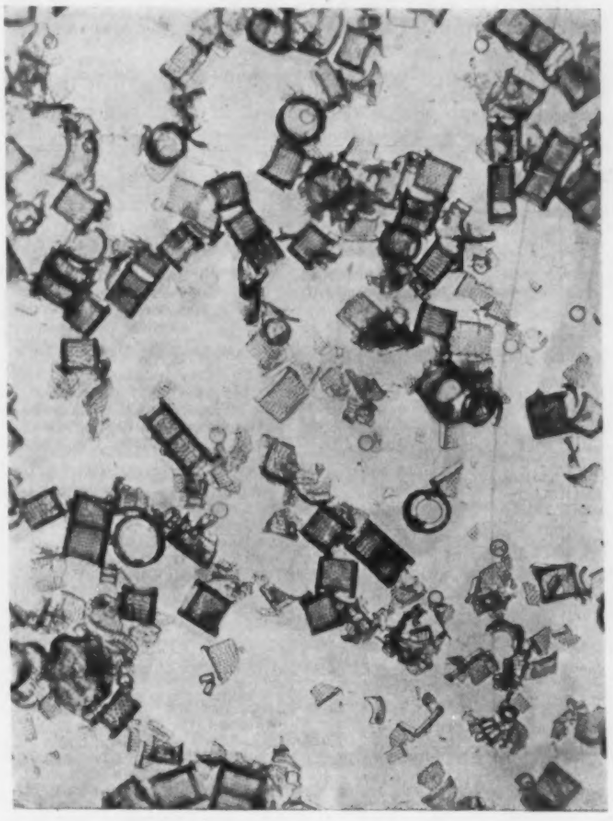

Fig. 2. Fresh water diatoms from Nevada. (Rock Products, March 16, 1929.)

Analyses of other American deposits are given in Fig. 4. That the silica is in its amorphous rather than its crystalline form has an important bearing on the chemical reactions of hardening cement as discussed later under "Effect of Admixtures on the Hydrolysis of Cement."

The color of diatomaceous earth when pure is white, its true specific gravity is 2.1 to 2.2 at 25 deg. C., which is the average specific gravity of hydrous silica. The apparent density of dry blocks of California material is about 0.45 (water taken as 1.) or 28 lb. per cu.ft., but blocks from some compact deposits weigh as much as 30 to 35 lb. per cu.ft. The apparent density of the pure, dry, loose powder varies from 0.12 to 0.25 or 8 to 16 lb. per cu.ft. It has a high power of absorption and will absorb from 1½ to 3 times its weight of water, depending upon its purity and the types of diatoms present. The absorptive power can be increased by calcination at 500-800 deg. C., as this drives off the combined water. It is highly porous and its porosity increases with temperature, although the volume remains constant.

At 870 deg. C. the diatoms change to β—tridymite which is the stable silicon oxide at this temperature. This change is accompanied by considerable shrinkage, the specific gravity of tridymite being 2.28. At 1,470 deg. C. the tridymite changes into still another form of silica known as cristobalite which is stable up to the melting point.

In its commercial form diatomaceous earth contains considerable moisture which can be removed by prolonged drying at 105 deg. C. The combined water is given in Fig. 4 for various deposits and varies from 3 to 8 per cent.

The following specifications for diatomaceous earth to be used as admixture for concrete have been suggested by the engineering department of the Southern Pacific Company at San Francisco.

Diatomaceous earth for use in concrete or hydraulic cement compositions shall be finely divided plankton marine diatomaceous earth free from clay and crystalline silica and shall conform to the following requirements:

Not more than 5 per cent of the material shall be retained on a 200-mesh screen.

Not more than 30 per cent by weight of the material shall be composed of particles which will settle in distilled water at 20 deg. C. at a rate greater than 22 cm. per hour.

Not more than 15 per cent by weight of the material shall be composed of particles which will settle in distilled water at 20 deg. C. at a rate slower than 0.22 cm. per hour.

The material shall not contain more than 10 per cent by weight of moisture.

Fig. 3. Salt water diatoms from Washington. (Canada Department of Mines.)

A moisture free sample of the material shall not show a loss on ignition at 1,800 deg. F. of more than 6.0 per cent. An ignited sample shall contain at least 90 per cent of silica and not over 4 per cent of alumina.

Weight per cu.ft. shall not be more than 10 lb. when fluffed through an 8-mesh screen.

The following percentages of admixture have been standardized by the Southern Pacific Company:

Concrete Mix	Percentage of Diatomaceous Earth Added
1:1½:3	2.0 by weight of cement
1:2:4	2.5 by weight of cement
1:2½:5	3.0 by weight of cement
1:3:6	4.0 by weight of cement

The North Carolina Highway Department specifies as follows (1925):

Diatomaceous earth for use in concrete or hydraulic cement compositions shall be finely divided Plankton Marine diatomaceous earth free from clay and crystalline silica and shall conform to the following requirements:

Not more than 1 per cent by weight of the material shall be retained on a 30-mesh screen.

Not more than 15 per cent by weight of the material shall be retained on a 200-mesh screen.

Settling tests with distilled water shall show not less than 55 per cent of the material remaining in suspension.

The material shall not contain more than 10 per cent by weight of moisture.

A moisture-free sample of the material shall not show a loss on ignition at 1,800 deg. F. of more than 6 per cent. An ignited sample shall contain at least 92 per cent of silica and not over 4 per cent of alumina.

The specifications call for: 2 per cent in 1:1½:3 concrete; 3 per cent in 1:2:4 concrete; 4 per cent in 1:2½:5 concrete (gravel coarse aggregate); and 5 per cent in 1:2½:5 concrete (crushed stone or slag coarse aggregate). These percentages are by weight of the cement content.

1. "Diatomite, Its Occurrence, Preparation and Use," by V. L. Eardley-Wilmot, Canada Department of Mines.
"Diatomaceous Earth," by Elliott S. Hastings—Rock Products, March 26, 1929.
Various Commercial Publications.

2. "An American Puzzolana and Its Effect on Portland Cement Concrete" by Dr. E. Lee Heidenreich, Rock Products, Sept. 29, 1928.
"Blending Fresno Pumicite With Cement" by J. B. Lippincott—Western Construction News—May 10, 1929.

Pumicite

Pumicite is a finely divided powder made up of small, sharp, angular grains of volcanic glass. It is formed by the violent and explosive eruption of volcanos which throw out this dust in great clouds. Ultimately the dust settles perhaps several thousand miles away from its original source and forms the beds of pumicite. Fig. 5 shows a sample of pumicite magnified about 500 times.

Great deposits of pumicite are found in Kansas, Nebraska, and Oklahoma and a deposit of considerable magnitude has recently been opened near Fresno in California. A typical analysis of the Fresno deposit is given below:

	Per Cent
Silica (SiO_2)	73.18
Iron oxide (Fe_2O_3)	1.09
Alumina (Al_2O_3)	15.46
Lime (CaO)	1.37
Magnesia (MgO)	0.36
Sulphur trioxide (SO_3)	0.71
Loss by ignition	4.17
Alkalies and undetermined	3.66
	100.00
Moisture at 105 deg. C.	0.33

It is seen that the analysis resembles very closely the analysis of diatomaceous earth. However, while silica in diatomaceous earth is almost wholly in the amorphous form, the silica in pumicite may be partly amorphous and partly crystalline or perhaps all crystalline according to how much deterioration has taken place since its deposit. Information on this point is not available on American deposits.

The fineness of the Fresno deposit is so that almost 100 per cent will pass through a 300 mesh sieve.

The absolute specific gravity is about 2.16, and the apparent specific gravity about 0.9 compacted and 0.7 loose.

Pumicite is a grayish white powder. It does not absorb water, and on calcination reacts in the same way as diatomaceous earth and other silicas.

The following specifications for pumicite to be used as a

Analyses of United States Diatomites[1]

No.	State	Locality	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Na_2O	K_2O	H_2O at 105° C.	CO_2+ Org.	Total	Remarks
1	California.....	Lompoc.....	88·40	2·05	1·13	0·34	0·52	n.d.	n.d.	6·08	0·31	98·83	Celite Co., No. 16 filter quarry.
2	"	"	86·24	3·05	1·02	0·18	0·63	"	"	5·62	1·20	97·96	" No. 38 Super-Cel "
3	"	"	80·40	6·88	2·12	0·86	1·17	"	"	6·12	0·61	98·16	" main brick quarry.
4	"	"	82·62	5·05	0·81	0·79	0·48	"	"	7·60	0·72	98·07	" used for concrete tests.
5	"	"	88·20	6·55	0·81	0·57	1·22	"	"	.....	0·80	98·15	" average (calcined).
6	"	"	90·50	3·71	1·29	0·28	0·70	.....	.....	0·56	0·18	97·22	" Super-Cel (calcined).
7	"	"	93·70	0·72	0·64	0·28	0·26	3·13	1·27	0·28	0·32	100·60	" Hyflo-Super-Cel (calcined).
8	"	Covina.....	82·80	6·06	1·94	0·51	0·92	n.d.	n.d.	5·88	tr.	98·11	Featherstone Co., for gasoline.
9	"	Bradley.....	84·11	3·55	1·29	1·24	0·86	"	"	5·12	0·88	97·05	Calif. Kieselguhr Co., best grade
10	"	"	82·64	5·23	1·61	0·74	0·70	"	"	6·00	0·30	97·22	Buttle Properties, mill product.
11	"	Monterey.....	77·88	6·80	1·90	0·33	0·13	3·37	2·02	5·20	2·56	100·19	Monterey Products Co., top beds.
12	"	"	78·40	6·76	1·04	0·51	0·64	n.d.	n.d.	7·76	1·30	96·41	Monterey Products Co., mill product.
13	"	"	78·72	5·60	1·90	0·51	0·04	5·28	1·57	5·70	1·06	100·38	Monterey Products Co., Cat Canyon.
14	"	Mt. Shasta...	88·35	3·24	0·84	0·37	0·45	nil	nil	5·74	0·88	99·88	Pitt river, No. 2 camp.
15	Oregon.....	Terrebonne...	86·74	4·64	1·46	0·85	0·37	"	"	5·80	0·40	100·28	Des Chutes river, best grade.
16	"	" ...	85·83	3·98	2·19	1·25	0·41	n.d.	n.d.	4·68	0·73	99·05	" " , filter product
17	"	" ...	84·32	5·20	2·42	1·53	0·39	"	"	3·92	0·70	99·51	" " , concrete product.
18	"	" ...	92·49	0·89	1·46	0·63	0·46	"	"	3·08	1·01	100·02	" " , bottom bed, large tubular diatoms.
19	Washington...	Burke.....	93·15	1·04	1·24	0·50	0·31	"	"	3·09	0·41	99·74	J. Webley deposit, best grade crude.
20	" ...	Kittitas.....	86·60	2·62	2·58	0·57	0·56	.....	.....	5·08	0·12	98·13	Great Western Silica Company, average grade.
21	Nevada.....	Carlin.....	81·13	7·42	3·03	1·79	0·31	.....	.....	4·86	0·62	99·16	Tri-O-Lite Co., average grade.
22	"	Virginia City.	91·45	2·60	0·83	0·70	0·35	.....	.....	3·41	0·97	100 51	Electro-Silicon Co., silver polish grade.
23	"	Reno.....	74·83	14·98	6·02	1·26	0·60	.....	.....	0·98	0·21	98·88	Main highway, 2 miles west of Reno.

[1] All samples collected and analysed at the Mines Branch, Ottawa, Canada.

Fig. 4. Analysis of United States diatomites.

part substitute for cement or as an admixture have been suggested by the Los Angeles County Flood Control District:

1. Silica (SiO_2) on a moisture free sample shall not be less than 70 per cent.
2. Alumina (Al_2O_3) on a moisture free sample shall not be more than 15 per cent.
3. Unit weight when loosely screened through an eight-mesh sieve must be at least 44 lb. per cu.ft.
4. Loss on ignition on moisture free sample must not exceed 5 per cent.
5. Moisture percentage as delivered not to be more than 5 per cent.
6. Must contain no more harmful percentages of organic materials as determined by colormetric test.
7. Must be of sufficient fineness to pass at least 90 per cent through a 325-mesh sieve.
8. A representative sample when mixed in the following proportions by weight: 1 part lime, 2 parts silica bearing co-mixture, sufficient water to give normal consistency and cured in a moist closet at 70 deg. F. shall develop at least 400 lb. per sq.in. compressive strength in 28 days.
9. Must consist of crystalline particles as determined by microscopic examination.

The strength test will give a measure of the "hydraulic properties" of the pumicite which again depends on the content of amorphous silica. Amorphous silica may be determined directly by boiling with caustic soda and determining the amount of silica which has gone into solution.

Workability (3)

Before the influence of admixtures on workability can be determined, a standard of workability must be fixed and an apparatus designed whereby a given mix can be compared with the accepted standard.

The now generally accepted definition of workability is that given by Pearson and Hitchcock (4) as: "That property which is indicated by the effort required to place the concrete so that a uniform and homogenous product is obtained."

It is at once realized that this term is far more involved than the definitions of other properties of structural materials. It is affected by several properties of the ingredients such as: mix, type, and gradation of the aggregates, the cement and admixtures used, the quantity of mixing water, and possibly still others.

The difference between the term workability and consistency should be noted:

> Consistency has been defined as a property dependent upon the amount of water used in a particular mix, whereas workability depends not only upon the water content but also upon the character and proportions of the materials used.

Any device for measuring consistency can be used, therefore, for comparing the relative workabilities of a given mix with varying water contents, but it cannot be used for comparing different mixes of cement and aggregate, and still less for comparing mixes with and without admixtures.

Nevertheless, the devices most commonly used for measuring workability such as the slump cone and the flow table are such that they indicate little less than the consistency.

Several most thorough investigations have been made of these and many other devices for measuring workability (5), and an apparatus called the improved penetration machine was finally decided upon as best suited to practical measuring of workability (Fig. 5A).

The apparatus measures the work required to drive three 1/3-in. rods down into the concrete mix to a certain depth, and is a further development of the apparatus first used by Pearson and Hitchcock in their original tests. The driving force is supplied by a small drop hammer and the workability index given the mix is the total energy in in.-lb. required to force the rods 11 in. into the mix.

It is apparent that indices affixed to a given mix, through tests with an apparatus of this kind, have in themselves no meaning. They are useful only insofar as they represent degrees of workability, as defined above, established by other means.

It is plain, however, that in the final analysis, the property workability can be determined only by the judgment of experienced observers who follow the batch from the mixer to its final resting place in the form. There is no conceivable way of measuring the effort described in the definition otherwise.

If the indices found by the penetration machine parallel such judgments, then and only then have they established their usefulness.

Fig 5. Kansas pumicite. (Rock Products, Sept. 29, 1928.)

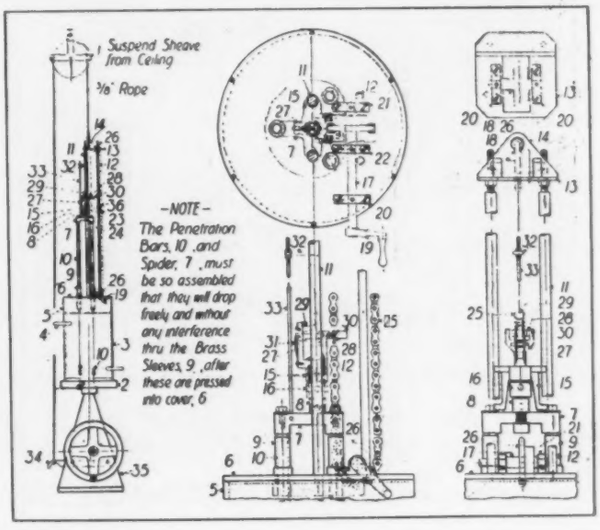
Suspend Sheave from Ceiling
⅛" Rope
-NOTE-
The Penetration Bars, 10, and Spider, 7, must be so assembled that they will drop freely and without any interference thru the Brass Sleeves, 9, after these are pressed into cover, 6

Fig. 5A. Assembly of apparatus, improved penetration machine. (A.S.T.M., 1928, Vol. 2)

3. Smith and Conahey: "A Study of Some Methods of Measuring Workability of Concrete"—Proceedings American Concrete Institute, Vol. 24, p. 24.
4. A.S.T.M., Vol. 23, 1923, Part II, p. 276.
5. Smith: "The Measurement of Workability of Concrete"—A.S.T.M., Vol. 28, Part II, p. 505.

There is still another condition which any measuring device must fulfill and that is, that a test repeated under exactly the same circumstances with the same materials must yield the same result within a reasonable latitude.

The proponents of the penetration machine have conducted many tests to determine to what extent their device complies with these stipulations. The results of some of these tests are shown in Fig. 6. It is seen that the workability indices vary in a sensible way when one of the factors affecting the workability is varied. It should be noted that where the workability index is high it indicates a harsh mix, hard to place, whereas if it is low it indicates a more plastic mix, easier to place.

What remains to be shown is that a given index corresponds to a given degree of workability regardless of how this workability has been brought about, whether by varying the cement content, the water, or the fineness modulus of the aggregates. Some adjustment will undoubtedly be necessary but a decided improvement should be shown as compared with the slump cone method which has to be adjusted for both fineness modulus and maximum size of aggregate.

If such improvement is not apparent, either the apparatus or our definition of the term workability has to be revised.

The penetration machine was developed principally to get a fair determination of the influence of certain powdered admixtures on the workability of the mix. For instance, if 2 per cent of diatomaceous earth is added to a given mix without changing the water content, the slump will be decreased. Nevertheless, it is evident that the workability has been improved. If sufficient water is added to bring the slump back to where it was before the admixture was added, the strength will probably be impaired.

Such tests as have been made with various admixtures seems to indicate that the penetration machine responds well to the changes in workability brought about by addition of admixtures.

Effect of Admixtures on Workability(6)

The effect of admixtures on workability has been tested by several investigators of which the following have used the penetration machine in its original or improved form: Pearson and Hitchcock from Bureau of Standards, and George A. Smith from the Celite Products Company. Pearson and Hitchcock have used the original penetration machine, while Smith has used the improved machine. The indices therefore cannot be directly compared, but the relative degree of workability is well demonstrated by both devices.

The actual results of these tests are very much of the same order, but the interpretations vary considerably and in some instances only a close study of the premises will reveal the reason for this variation.

In Fig. 7 is shown the influence of diatomaceous silica on three mixes with varying percentages of admixture.

It should be noted that in these tests the flow has been kept constant at 100. This means that additional water has been used with the admixture over and above what was required for the plain mix. This additional water alone would increase the workability except perhaps for the 1:3:6 mix, but this increase would naturally be small as compared to the increase brought about by the admixture.

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6. "Economic Value of Admixtures" by J. C. Pearson and F. A. Hitchcock—Proceedings American Concrete Institute, Vol. 20, p. 312. "Workability Symposium"—American Concrete Institute, Vol. 24, p. 24-100.
"Effect of Lime and Other Powdered Admixture in Concrete" by O. A. Alerams—A.S.T.M., Vol. 20, Part II, p. 149.
"A Penetration Test for the Workability of Concrete Mixtures, etc." by J. C. Pearson and F. A. Hitchcock—A.S.T.M., Vol. 23, Part II, p. 276.

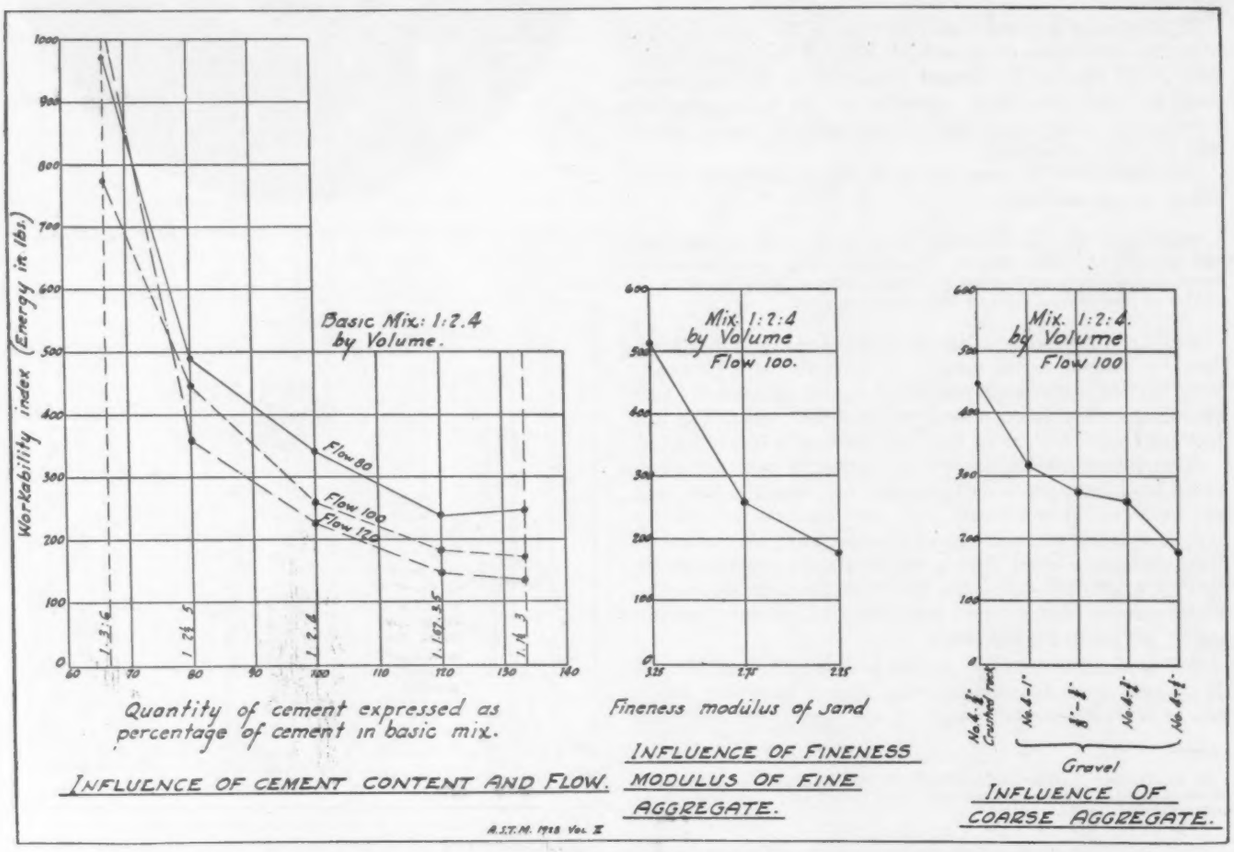

Fig. 6. Influence of cement content and flow, on fineness modulus of fine aggregate, and of coarse aggregate.

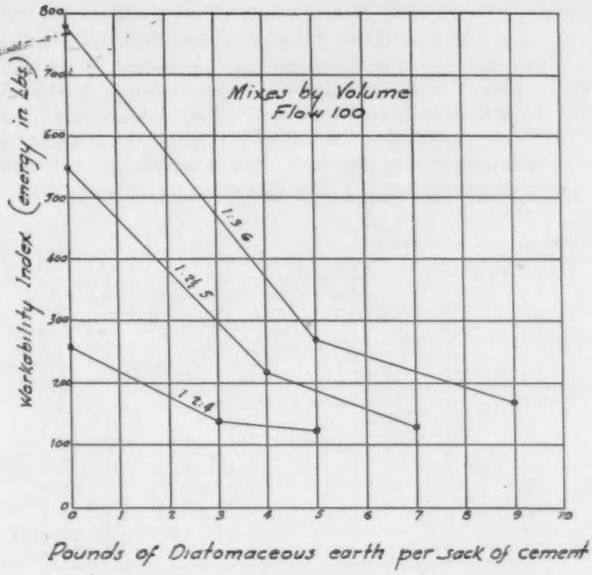

Fig. 7. Influence of diatomaceous silica on workability. (A.S.T.M., 1928, Vol. 2.)

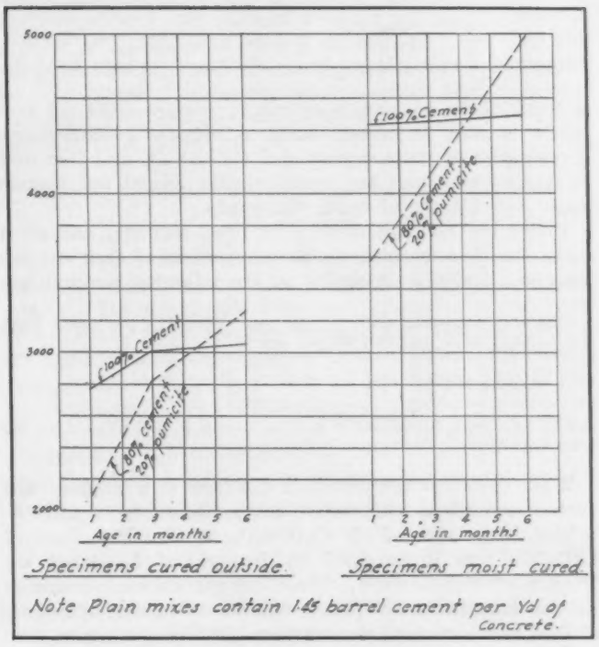
100% Cement
80% Cement 20% pumicite
Age in months
Specimens cured outside
Specimens moist cured
Note Plain mixes contain 1.45 barrel cement per Yd of Concrete.

Fig. 8. Influence of admixtures on workability. (Proceedings American Concrete Institute, 1928.)

In Fig. 8 are shown some similar tests with admixtures of lime, kaolin, talc, and diatomaceous earth, and with additional cement.

Very few corresponding tests have been made with pumicite, the only known test being plotted in Fig. 8.

In analysing these tests, the theory is advanced that materials like pumicite and cement influence workability somewhat in the same way as does a fine sand(7). It is significant that 10 lb. of pumicite has the same volume as 33 lb. of cement and gives the same improvement in workability. Also, the addition of these two materials in the given quantities, if considered as sand, would lower the fineness modulus from 2.75 to 2.35, which would correspond to a lowering of the workability index from 260 to 190, while actually they lowered the index from 260 to 175.

Diatomaceous earth, lime, and other materials which absorb water act in a different way; they might perhaps be considered as increasing the viscosity of the water and thereby preventing segregation of the materials and acting in a way as a lubricant. The measure of the value of this type of admixtures might then be their capacity for absorbing water.

Constitution and Hydrolysis of Portland Cement

The average commercial portland cement consists of, for the major part, the following three components:

Lime (Ca.O)
Alumina (Al_2O_3)
Silica (SiO_2)

the balance being made up of:

Magnesia (MgO)
Iron oxide (Fe_2O_3)
Sodium oxide (Na_2O)
Potassium oxide (K_2O)
Sulphur di-oxide (SO_2)

By microscopic analysis (8) at the Bureau of Standards it was shown that the three major components for all practical purposes appear in the following combinations:

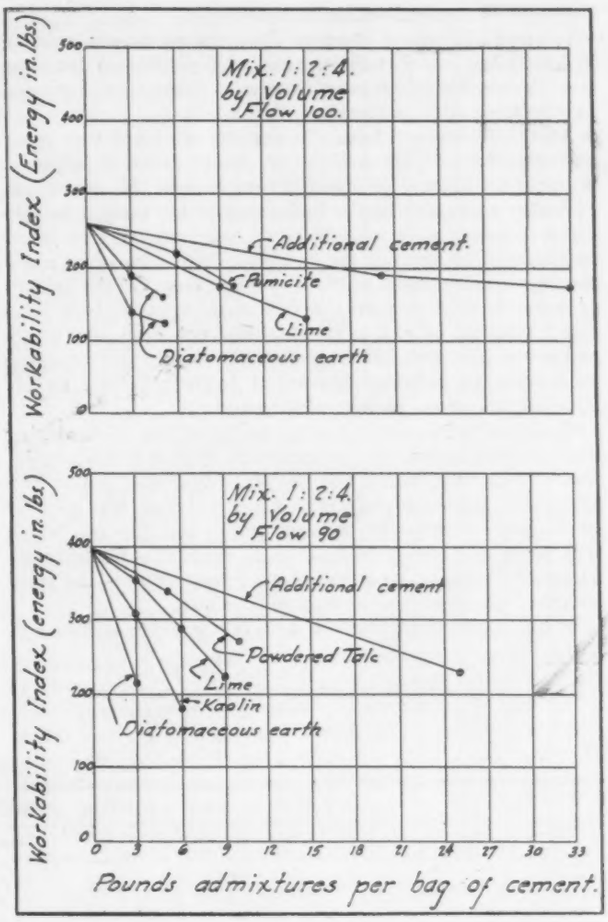

Fig. 8A. Strength tests showing effect of large percentages of Fresno pumicite. (Los Angeles County Flood Control District.)

7. Talbot and Richart in University of Illinois Bulletin No. 137, p. 92.

8. Industrial Engineering Chemistry, Vol. 7, 1915, and Transactions Faraday Society, Vol. 14-15.

3 $CaO.SiO_2$
2 $CaO.SiO_2$
3 CaO,Al_2O_3

and that these compounds constitute more than 90 per cent of the clinker. In cement burnt at too low a temperature a compound of the composition 5 $CaO.3Al_2O_3$ and free lime (CaO) may appear, but sound cement should not contain more than a trace of these compounds.

Under the assumption that all lime, alumina, and silica enter into these compounds, the proportions of each one can then be calculated. A cement of the following composition:

CaO 63.2 per cent; Al_2O_3 7.7 per cent; SiO_2 22.4 per cent; MgO, Fe_2O_3, Na_2O, K_2O, and SO_3 6.7 per cent.

will consist of:

35.2 per cent 3 $CaO.SiO_2$; 37.7 per cent 2 $CaO.SiO_2$; 20.4 per cent $CaO.Al_2O_3$. (See appendix.)

When these two compounds in the form of a finely ground powder are mixed with water each compound will hydrolize.

The hydrolysis of 3 $CaO.Al_2O_3$, 3 $CaO.SiO_2$ and 2 $CaO.SiO_2$ was investigated by Bogue and Lerch at the Bureau of Standards(9). These compounds were prepared in the laboratory and their behaviour during hydrolysis studied under various circumstances.

It was found that the aluminate is stable in saturated lime solutions but that both silicates will liberate lime even in a concentrated solution of CaO.

The hydrolysis of these two compounds in a saturated lime solution will continue until a product of the composition $CaO.SiO_2$ is reached which is stable.

It should be noted however that the conditions existing in hardening portland cement are vastly different from the conditions under which these tests were made, as also pointed out by the two investigators.

At the laboratory tests the amount of liquid was great as compared with the amount of clinker material, while in concrete the amount of liquid is very limited. If the amount of water available for the hydrolysis of the cement in concrete is great, as it may be at or near construction joints in hydraulic structures, the hydrolysis will take place along the lines demonstrated in the laboratory tests. If the amount of water is greater than that which corresponds to a saturated solution of the available lime, not even the monocalcium silicate will be stable and the concrete will crumble to a white or yellowish powder of hydrous silicate as has been demonstrated in several structures.

Under ordinary circumstances, as prevailing in hardening concrete, the hydrolyzed material will form a colloidal solution or gel surrounding the unhydrated clinker grains and gluing the aggregate together. An equilibrium will possibly be reached, between the clinker grains and the gel, which will bring further hydrolysis to a standstill, unless some outside influence such as percolating water upsets the equilibrium and causes the process to continue.

In this state of equilibrium a certain amount of lime will have been liberated in the form of calcium hydroxide, which through percolation or sweating will be carried to the surface where it will react with the carbon dioxide in the air and form lime carbonate—the well known incrustations.

An attempt has been made to determine the amount of free lime present in hardened cement which has not been subject to percolation.(10) The following results were found:

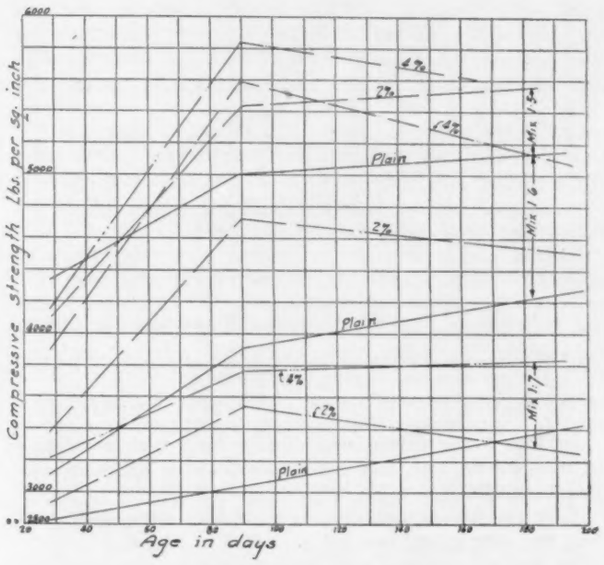

Fig. 9. Strength tests with admixtures of diatomaceous earth from California diatoms—Slump". (Canada Department of Mines)

"The silicate complex," in connection with the aluminate, constitutes the cement gel which glues together the aggregates as referred to above. By dividing by the respective molecular weights it is found that the constitution of the silicate complex corresponds almost exactly to the compound di-calcium silicate ($2CaO.SiO_2$).

This checks very closely with the findings of the Bureau of Standards, that the tri-silicate gives off its lime much more freely than the di-silicate. It seems reasonable to assume that one-third of the lime in the tri-silicate is held more loosely than the rest of the lime and will go into solution even in good concrete.

Effect of Admixtures on the Hydrolysis of Cement

If means can be found to bind the lime liberated by the tri-silicate into an insoluble compound, leaching out of lime should be prevented in well made concrete and additional hydraulic properties given to the cement. In concrete subject to excessive percolation the deterioration will go on still further as previously pointed out, but it is thought that

9. Journal of Physical Chemistry, Vol. 31, p. 1627.

10. "On the Constitution of Hardened Portland Cement" by G. Assarsson and N. Sundius—Sveriges Geologiska Undersokninger—No. 23, Vol. 2.

TABLE I

	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	CO_2	Total	Remarks
Water-free cement	23.0	5.5	2.5	1.6	64.2	3.2	100	Before Hydrolysis
CaO in $Ca(OH)_2$	....	...	...	...	11.2	...	11.2	
$CaCO_3$	....	...	...	...	4.1	3.2	7.3	
3 $CaO.Al_2O_3$	....	5.5	...	...	9.0	...	14.5	
Fe_2O_3	....	...	2.5	...	....	...	2.5	After Hydrolysis
Silicate complex	23.0	...	...	1.6	39.9	...	64.5	
							100.0	

this condition should be prevented by more careful placing rather than cured by binding the lime.

The only practical way of binding lime into an insoluble compound is by means of finely ground amorphous silica which will react with lime at ordinary temperature and form mono-calcium silicate ($CaO.SiO_2$) which is insoluble in water.

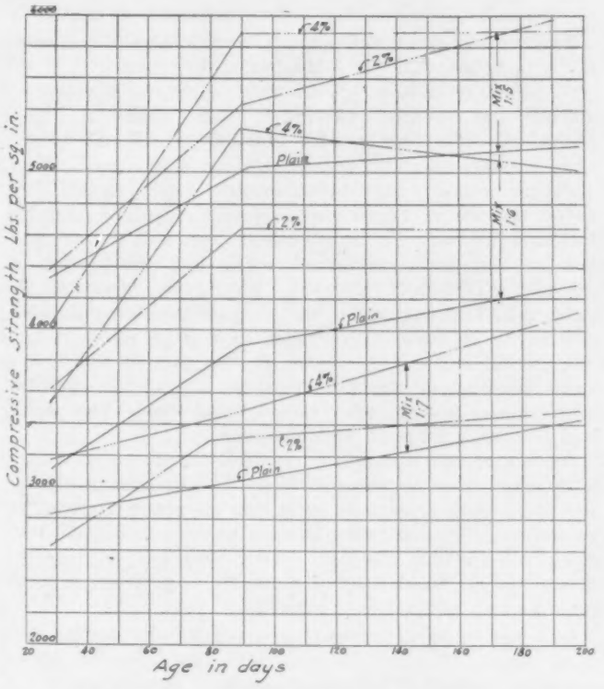

Fig. 10. Strength tests with admixtures of diatomaceous earth from British Columbia fresh water diatoms—Slump". (Canada Department of Mines.)

Roman cement was made by mixing lime with puzzolana, which is earth containing amorphous silica, and concrete made from this material has stood for centuries.

That the reaction between lime and silica actually does take place in concrete where part of the cement has been replaced with silica was demonstrated by Lowenthal and Paulson(11) and admixtures of puzzolana to portland cement concrete have been used by European engineers since the early seventies for concrete in hydraulic structures.

If it is desired to add sufficient silica to bind one-third of the lime of the compound $3CaO.SiO_2$ the amount may be determined by the following formula:

$$S = 1.07A - 1.78B - 2.00C$$

for a cement containing A per cent CaO, B percent Al_2O_3, and C per cent SiO_2. A, B and C refer to the percentages in ignited state, and S to the pure amorphous silica in its ignited state expressed in per cent of the cement. After S has been determined, allowance must be made for moisture, impurities, and crystalline silica in the commercial product used as admixture. Details of these calculations are given in an appendix.

Diatomaceous earth as a rule contains a very high percentage of amorphous silica and would therefore be preferable for control of free lime. However, it would require as much as 18 per cent of this material to obtain the desired effect and such a mix would not be practical with the diatomaceous earth in its natural form. Certain European cements (moler cement) contain over 20 per cent diatomaceous earth, but in these cements the moler (which is a form of diatomaceous earth) is burnt and then added to the cement clinkers and ground together with them. In this way an excellent product is obtained which has given very satisfactory results in concrete structures exposed to both salt and fresh water.

Effect of Admixtures on Compressive Strength of Concrete

The compressive strength of concrete, in the past often the only requirement specified, is very often of but secondary interest. The permissible stress in concrete members is held at a fraction of the specified strength and rightly so, and in the great majority of reinforced concrete members the actual concrete stress is far less than the permissible stress. The goal to be worked toward in ordinary concrete construction is a concrete of moderate but uniform strength rather than a concrete of high strength.

If methods can be devised whereby uniform strength and assured integrity can be obtained even at a sacrifice of strength a great step forward has been taken. In one portion of the preceding discussion one factor influencing uniformity has been dealt with, namely workability; in another, a factor influencing the integrity, namely the chemical reactions, has been touched upon, and it has been pointed out that certain powdered admixtures act beneficially in both respects. It remains to be shown how these admixtures influence the strength, it being again remembered that an increase in strength is not the object and that a moderate decrease may even be tolerated.

Figs. 9 and 10 show results of tests by the Canada Department of Mines with 2 and 4 per cent diatomaceous earth of marine and fresh water diatoms. Table II shows results of tests by the North Carolina Highway Department with 1.5 to 8 per cent of marine diatomaceous earth. Fig. 11 shows the results of tests by Missouri Highway Laboratories with 10 per cent of Kansas pumicite. All these tests indicate that small percentages of these admixtures do not impair the strength of the concrete.

The application of the water-cement ratio law to mixes containing admixtures is interesting, and Fig. 12 gives results of tests by the Johns-Manville Corporation with admixtures of marine diatomaceous earth. In this diagram points A and C correspond to the same mix, plain and with admixture, and gaged to the same flow, while points A and B correspond to the same mix, plain and with admixture, and with the same water-cement ratio. In other words, if the mix containing admixture is gaged to the same flow as the plain mix, the strength will be the same, although the mix contains more water in relation to cement. If the same amount of water is added in both cases, the strength of the mix containing admixture will be higher. The horizontal distances between the two curves corresponds approximately to an amount of water equal to 200 per cent of the weight of the admixture, therefore in predicting the strength of a mix containing admixture of marine diatomaceous earth the water-cement ratio law may be applied provided the water-cement ratio is based on the actual quantity of water used less an amount corresponding to a certain per cent of the weight of the admixture. For the product marketed by the Johns-Manville Corporation this per cent is 200. For other products it will be different, but figures are not yet available for other types of diatomaceous earth. For pumicite 30 to 60 per cent of the weight of pumicite is usually deducted from the total amount of water.

Effect of Admixtures on the Permeability of Concrete

It is generally believed that admixtures of diatomaceous earth and pumicite will increase the impermeability of con-

11. 14th International Congress of Navigation—Cairo, 1926.

crete due to their great fineness, aside from the effect they may have on the deterioration of the concrete. Such tests as have been made, however, are not conclusive. Very elaborate penetration tests have been carried out during the last two years by the Swedish Board of Waterfalls at Lilla Edet powerhouse, but in spite of every conceivable precaution the results are contradictory. The same refers to some extent to tests by the Pacific Gas and Electric Company and the Johns-Manville Corporation. All these tests are being continued and it is believed that eventually the technique will be improved so that a definite answer can be given. It is intended in a later report to return to this subject.

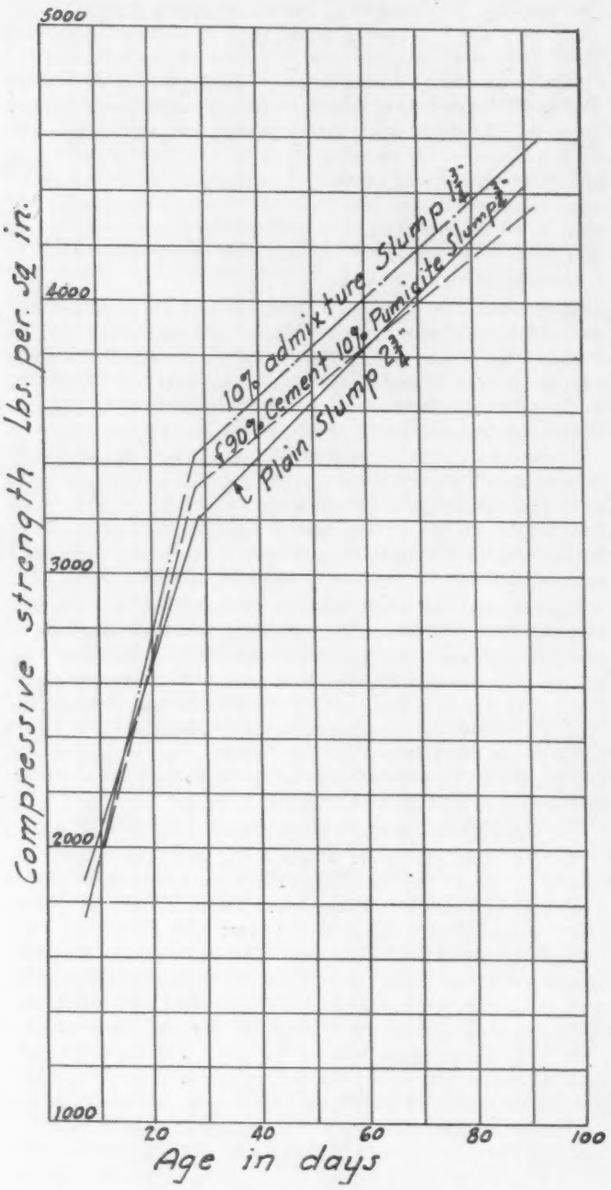

Fig. 11. Strength tests with admixtures of Kansas pumicite. Note: Mix, 1:2:3½; w/c ratio, 0.735; comb. F.M., 5.64. W/c ratio refers to "net" water. Additional water was used amounting to 20 per cent of weight of pumicite. (Missouri Highway laboratories. Rock Products, Sept. 29, 1928.)

Economic Value of Admixtures

The economic value of admixtures is a highly controversial subject and shall be treated only very briefly.

A principal item in the cost of concrete is the cost of placing, and increased workability will decrease this cost. Increased workability may be obtained by the use of one of several agencies such as finer aggregate, additional water, additional cement, substitution of gravel for crushed rock, or by the use of admixtures. However, these workability factors affect not only the workability, but also the strength. Smaller aggregate, additional water and substitution of gravel for crushed rock will, as a rule, decrease the strength; additional cement will increase the strength; while admixtures in small percentages have little effect in this respect. In a previous chapter it was pointed out that a small decrease in strength might be tolerated if uniform strength was gained, other things being equal. This would lead to consideration of finer aggregate.

Often a certain strength is specified and increased workability might then be obtained by finer aggregate in connection with more cement or by a coarser aggregate and an admixture. Some admixtures such as marine diatomaceous earth will increase the yield slightly but will decrease the specific weight which may be a disadvantage in some structures and an advantage in others.

In a few cases an increase in strength may have an economic value. If so, additional cement may be preferable to any other method of obtaining increased workability.

The value of admixtures for obtaining increased workability will therefore depend on the specific circumstances and the problem must be solved for each individual case—no general rule can be formulated.

The question of substituting silica admixtures such as pumicite for large percentages of cement, as treated in a previous discussion, is of profound importance, both from an economic and a technical standpoint. The Los Angeles County Flood Control District estimates that a saving of from 5.4 to 17 per cent of the cost of the cement would be possible and a concrete better suited for hydraulic works obtained if such a substitution is made. This question merits the most thorough investigation.

As far as chemical reaction with cement is concerned, only amorphous silica is active and the value of any commercial admixture depends upon its content of this form of silica. The cement described in the preceding discussion would require 9.3 per cent of pure amorphous silica admixture to bind its free lime. If it be assumed that amorphous silica constitutes one-half of the silica content in Fresno pumicite* the ratio of pumicite to cement should be:

* The percentage of amorphous silica in Fresno pumicite is as yet unknown, but German trass, a similar product, has been found to contain 31.5 per cent amorphous and 30.2 per cent crystalline silica.

TABLE II—Comparative Compressive Tests of Concrete with Admixtures of Marine Diatomaceous Earth (Expressed in Percentage)—By North Carolina Highway Dept.

	Mix—1:1½:3		Mix—1:2:4		Mix—1:3:6	
	28 days	1 year	28 days	1 year	28 days	1 year
Plain Concrete	100	100	100	100	100	100
1½ per cent admixture	98	103	111	110	101	109
3 per cent admixture	95	94	106	114	99	111
4½ per cent admixture	..	..	106	107	103	118
6 per cent admixture	..	..	103	107	104	105
8 per cent admixture	..	..	..	..	106	111

$$\frac{9.3}{\frac{1}{2} \times 73.18} \text{ or } 25.4 \text{ per cent}$$

Extensive tests of concrete made with 80 per cent portland cement and 20 per cent pumicite have been carried out by Los Angeles County Flood Control District and some of the results are shown in Fig. 8A.

As might be expected, in the early strength of cement—pumicite concrete is less than that of plain cement concrete. This is due to the fact that the initial set and the early strength of concrete is caused by the hydrolysis of the tri-calcium silicate; as there is less tri-silicate in the cement-pumicite mixture the early strength is less. Soon, however,

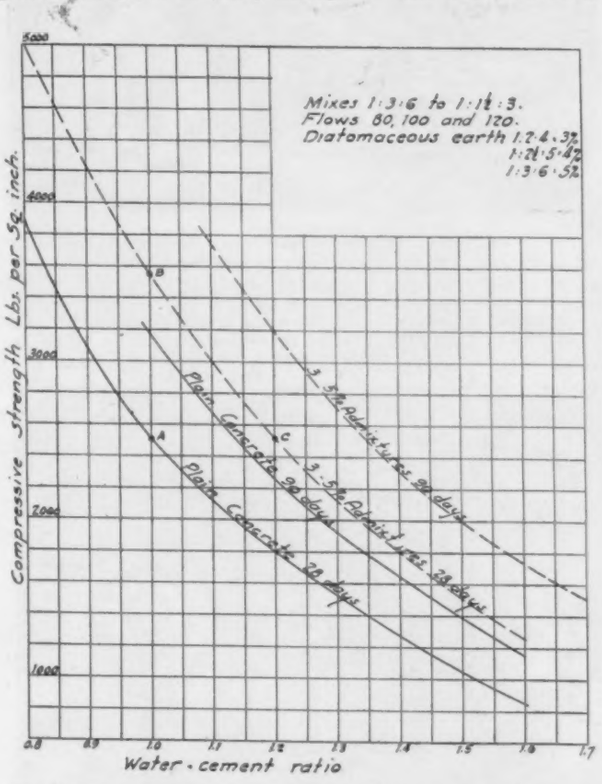

Fig. 12. Water-cement ratio strength relation for admixtures of from 3 to 5 per cent marine diatomaceous earth. (Tests by Celite Products Company.)

the tri-silicate begins to decompose and the final strength is due to the di-silicate and, in the case of cement—pumicite concrete, to the mono-silicate. Through the pumicite an additional hydraulic factor has been introduced and the easily dissoluble lime has been replaced by the indissoluble mono-calcium silicate. That also an appreciable amount of inactive material has been added should not be overlooked when weighing the advantages.

The final strength of the cement-pumicite mixture therefore equals or even exceeds the plain mixes. The economic possibilities of this fact are treated in the following discussion.

APPENDIX

1. Calculation of Percentages of Compounds 3 $CaO.SiO_2$, 2 $CaO.SiO_2$, and 3 $CaO.Al_2O_3$—

	Per Cent	Molecular Wt.
CaO	A	56.07
Al_2O_3	B	101.94
SiO_2	C	60.06
3 $CaO.SiO_2$	X	228.27
2 $CaA.SiO_2$	Y	172.20
3 $CaO.Al_2O_3$	W	270.15

Percent lime bound in 3 $CaO.Al_2O_3$: $\frac{B}{101.94} \times 3 \times 56.07 = 1.65\ B$

Percent lime available for silicates: $A - 1.65\ B$

Then: $\frac{X}{228.27} \times 60.06 + \frac{Y}{172.20} \times 60.06 = C$

And: $\frac{X}{228.27} \times 3 \times 56.07 + \frac{Y}{172.20} \times 2 \times 56.07 = A - 1.65\ B$

And: $W = 1.65\ B + B$
Or: $X = 4.07\ A - 6.72\ B - 7.60\ C$
And: $Y = 5.07\ B + 8.60\ C - 3.07\ A$
And: $W = 2.65\ B$

2. Calculation of percentage of silica required for binding one-third of the lime in the compound 3 $CaO.SiO_2$ into the compound $CaO.SiO_2$—

If the required percentage is S,

Then: $S = \frac{X \times 60.06}{228.27} = 1.07\ A - 1.77\ B - 2.00\ C$

Part Two—Mixing and Placing Concrete for Concrete Bench Flumes[2]

Flumes, ditches and open conduits in general are oftentimes inaccessible and no two jobs of construction can be handled in the same manner.

This part of the report is a narrative of the experience of different companies on various open conduit jobs. Much dependence is placed upon illustrations to describe the several types of construction plant used. It is probably safe to say that no two jobs are alike and that much ingenuity must be used in each case. For instance, one job may be easy of access at several points along the line by mountain roads, while on another it may be necessary to transport all the materials along the right-of-way itself. The report not only covers transportation facilities but also aggregate plants, concrete plants, forms, reinforcing and methods of placing concrete.

Report of The San Joaquin Light and Power Corporation on Construction Methods Used in Rebuilding the Crane Valley Conduit

IN THE Crane Valley system, the San Joaquin Light & Power Corporation has some twelve miles of flow conduit and in this distance nearly every conceivable type of construction is used. Many of the original designs were faulty and in many instances had failed to a point where replacements were necessary. Furthermore, nearly all of the conduit was under capacity. Therefore, it was decided to rebuild all the conduits to the proper capacity and, owing to the economic situation, use as much as possible of the existing structures. Such a policy naturally involved some interesting problems.

The concrete plant, transportation facilities and construction methods in general necessarily had to apply to many different types of conduit section. There are several miles of box flume included in the total distance but it is thought well to give the above general description of the work in order to bring out the fact that the construction methods had to be fitted to the conduit in general instead of being especially designed for box flumes.

The principal problem in flume construction is transportation and a consequent problem is to decide whether to es-

[2] Prepared by H. K. Fox, H. Keesling, K. A. Reeder.

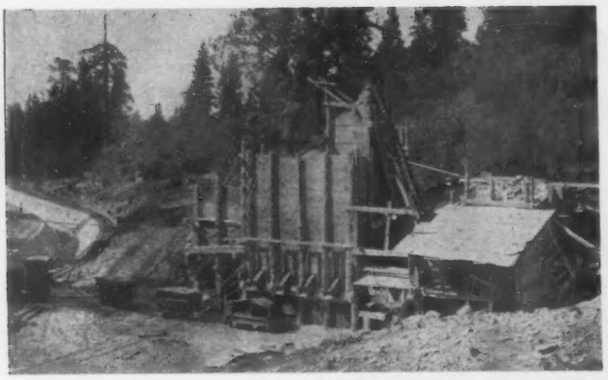

Fig. 1. Suitable rock was very difficult to obtain but small quarry sites were found along the line and crushing and screening plants built. The crushed material was hauled in yard cars and usually about three cars to a train. Long coupling rods were necessary in order to take care of the curvature.

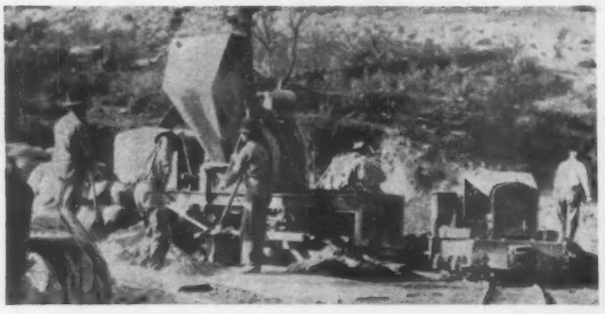

Fig. 2. Occasionally a comparatively level spot could be found of sufficient size to store materials, set up the mixer, and construct a spur.

tablish a central mixing plant or to set up a movable plant at strategic points along the line. Due to the nature of our work, we used a combination of both.

We used narrow-gage railroads, the gage being 18 in. and the rail 12 lb. to 20 lb. Locomotives were built in the company shops, using Ford engines and a specially designed transmission. The track and rolling equipment proved very satisfactory. This was about the only possible means of transportation feasible on steep side-hill country. The road bed was located on the banks of the ditch, across the tops of the flumes and sometimes on trestles built for it, and was kept as close as possible to the work. In general, concrete was dumped directly from side dump cars into the top of the forms. Flat cars were used for hauling cement, reinforcing, lumber, form panels, etc. The maximum load with 2 per cent grades was about five tons. This particular capacity fitted well with the capacity of 5-ton trucks which delivered materials to the railroad at any points where it was accessible.

Panel forms were used almost entirely. These are a great saving, especially on fairly straight work. On curves, the cost is greatly increased, but there is probably some saving by using panels.

Reinforcing was all fabricated in the field. A set of rolls made up of pipe was devised for straightening out mesh reinforcing. The locomotives were used to pull the mesh through these rolls. It could then be handled and put into place very easily.

No new gunite flume was constructed but several sections of old flume were rebuilt and enlarged in gunite.

Concrete materials were obtained by quarrying rock along the line and a simple crushing and screening plant was built. Electric motors were used in the plant.

The general procedure was to start at the upper end of the conduit. By so doing it was possible to put in temporary sack dams at convenient points and allow the water to run down. To provide water for the mixer and curing of concrete, a portable pump would be set up at the dam and

Fig. 3. The frame of the mixer was mounted on wheels and axles and was therefore easily moved from one location to another. In setting up, it was jacked up off the wheels and moved to one side of the track. In some cases it was possible to find enough level ground while in others a platform was built over the conduit as shown.

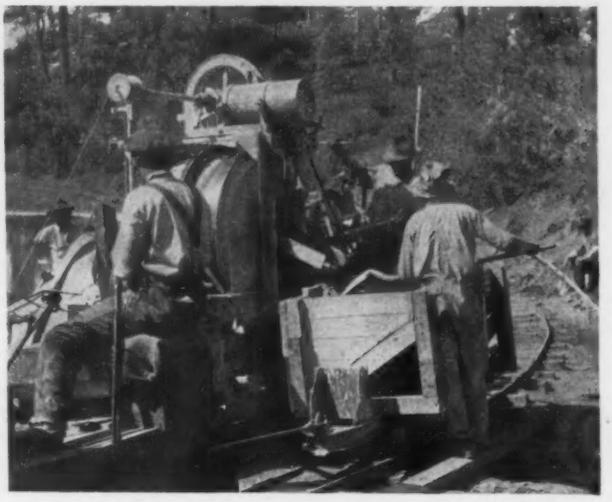

Fig. 4. Side dump concrete cars were built on the job, using the running gear of steel dump cars commonly known as the Koppel type.

a pipe line run out to the point ahead where the next dam would be built.

The accompanying progress pictures will convey more information regarding our methods then detailed description.

Report of Pacific Gas and Electric Company on Construction Method Used in Building The Tahoe Flume

The concrete bench flume which replaces the wood stave Tahoe syphon is located entirely on solid bench excavated into the hillside. Above the bench and paralleling it is a road constructed at the time the bench was excavated. This made the problem of pouring simpler than at the other sites.

The concrete plant was located 200 ft. below the down-

stream end of the flume, the site being governed by space on the canal berm available for storing of concreting materials. The mixer was sufficiently elevated to allow a steel dump body Ford truck to back underneath the delivery spout. The steel body of the truck was fitted with an end gate from which the concrete was allowed to spout directly, in the case of the floor pour, or into the concrete buggies when the walls were being poured.

Details of construction were as follows: After the bottom of the bench had been properly surfaced, header boards were carefully set to line and grade on each side. The reinforcing for bottom and side walls was next placed for a section several hundred feet long. Over the steel, two runways were built to form tracks for the Ford truck to run on. Concrete was dumped from the mixer into the truck body, hauled down an incline to the flume grade and along this grade to the end of the section, where the steel was in place. Here the truck turned around and backed 200 ft. over the runways to the point of pour.

Fig. 5. Spurs and sidings were provided in the track wherever possible and trains hauling concrete had right of way.

Fig. 6. In some places the track was laid on the cross ties of the flume trestles and to distribute the load long trains were used.

Here the concrete was spouted directly from the steel body of the truck. On being emptied the truck returned to the mixer. Meanwhile a second truck was loaded and on its way to dump. Railroad spikes to hold the steel wall forms were set in the floor before the concrete hardened.

After a section of steel forms was ready for concrete a runway was built over the top of it, but entirely independent of it, so that no vibration would be communicated to the walls while hardening. Concrete was hauled over the road constructed along the flume in 1-ton Ford trucks to the

TABLE I—Unit Costs

	Total Costs		Per Cu. Yd. Excavation (12,000 Cu. Yd. Total)		Per Cu. Yd. Concrete (814 Cu. Yd. Total)	
*Excavation:						
Labor	$6,690.17		$0.558		$8.219	
Miscellaneous	1,006.88	$7,697.05	0.082	$0.640	1.237	$9.456
Forms:						
Labor	3,642.19		.....		4.474	
Lumber (10,300 b. ft.)	292.50		....		0.359	
Forms steel,						
Depreciation	432.00		....		0.531	
Miscellaneous	662.38	$5,029.07	....		0.814	$6.178
Concrete:						
Labor	$6,842.15		....		$8.406	
Transportation	6,462.20		....		7.939	
Cement (4,732 sacks)	3,777.92		....		4.641	
Rock (728 cu. yd.)	1,899.60		....		2.334	
Sand (435 cu. yd.)	341.21		....		0.419	
Steel (126,748 lb.)	3,223.07		....		3.959	
Miscellaneous	1,605.19	$24,151.34	....		1.972	$29.670
		$36,877.46	....			$45.304

*—A gasoline shovel was used for excavating the bench. The miscellaneous costs shown above include transportation expenses; loss, depreciation and maintenance of tools and equipment; stores expense, and supplies consisting of blasting caps, fuse, powder, gasoline.

Fig. 7. The floor of the ditch was placed first, but experience has indicated that it would be preferable to make the section monolithic. A very dry cement was used and common labor was employed to place and finish it.

Fig. 8. At this point it was impossible to build the track on the upper side of the work. The mixer was located as near as possible and the concrete buggied out to the horns.

section to be poured. Here the concrete was emptied into 6-cu.ft. buggies and deposited in the steel forms.

Up to 100 ft. of wall forms (50 ft. of flume), were set up and poured during a 10-hour shift. Some cost figures are shown below.

The transitions and a short section of flume were not constructed until May, 1928. Wood forms were used for this purpose as the metal forms were being used at flumes No. 3 and No. 5.

Fig. 13 shows construction details of flume.

Report of Pacific Gas and Electric Company on Construction Methods Used in Building a Gunite Flume

The Cross-over canal of this company is located in Nevada County and conducts water from Lake Valley reservoir to the Drum canal. The gunite flume is located on the west slope of the mountains about 1½ miles northeast of Emigrant Gap and is at an elevation of about 5,100 ft.

The style of conduit was decided upon for the reason that the 2,031-ft. section of the canal passes over a volcanic ash formation which would not have made a good earth ditch, and also to get some first-hand information about gunite structures in snow territory.

The accompanying sketch shows a cross section of this conduit. It is a bench-type flume 4 ft. wide inside by 3 ft. 3 in. deep, made of reinforced gunite having walls and bottom 2½ in. thick, and built on a 6½ ft. bench.

The sand and cement was hauled by truck from Emigrant Gap to the foot of the hill below the bench, and a 1-cu.yd. bottom dump wagon hauled by a Caterpillar Thirty distributed the required amounts in stock piles along the bench at approximately 150-ft. intervals.

Flexible wooden panels fifteen ft. long were built at the site for the outer sides of the walls.

The gunite was placed under contract with the following conditions written into the contract:

The owner will handle at their own cost and expense:

The necessary grading, preparing the bench and grade and alignment stakes.

Room and board at their camp at the Gap at $1.50 per day for our operators.

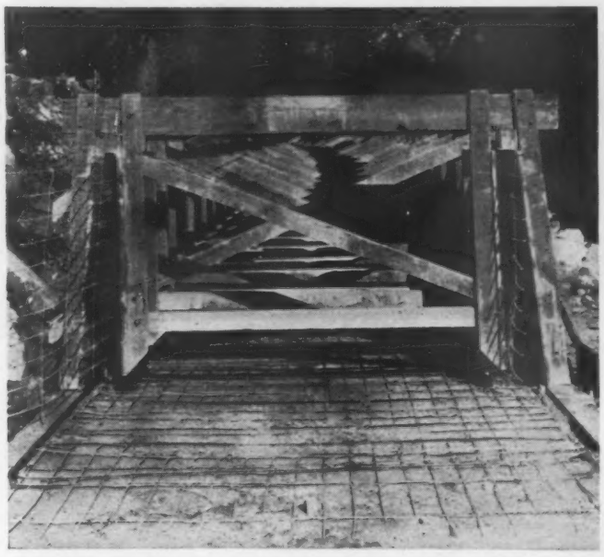

Fig. 9. Box flume forms and steel. The panels and bracing were assembled in a definite order and were held together by bolts. About 300 ft. of form was used to provide a 100-ft. pour.

Fig. 10. Transitions from box flume to trapezoidal ditch sections were standardized so far as possible in order to use panel forms. These forms could be hauled on flat cars from one point to another and proved very satisfactory.

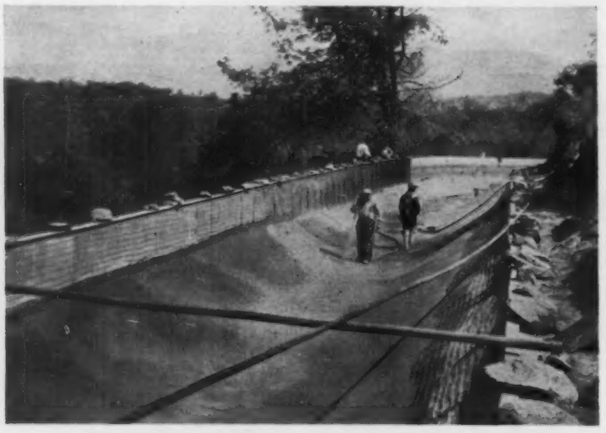

Fig. 11. This section is primarily a lined ditch with a vertical concrete wall on the down side. The old lining failed and it was prepared for a new lining and also the wall raised. One of the problems was to prevent crowding at the point where the ditch lining joins the wall and this was done by preventing a bond between the new and the old work.

Fig. 12. Tahoe flume, Pacific Gas and Electric Company.

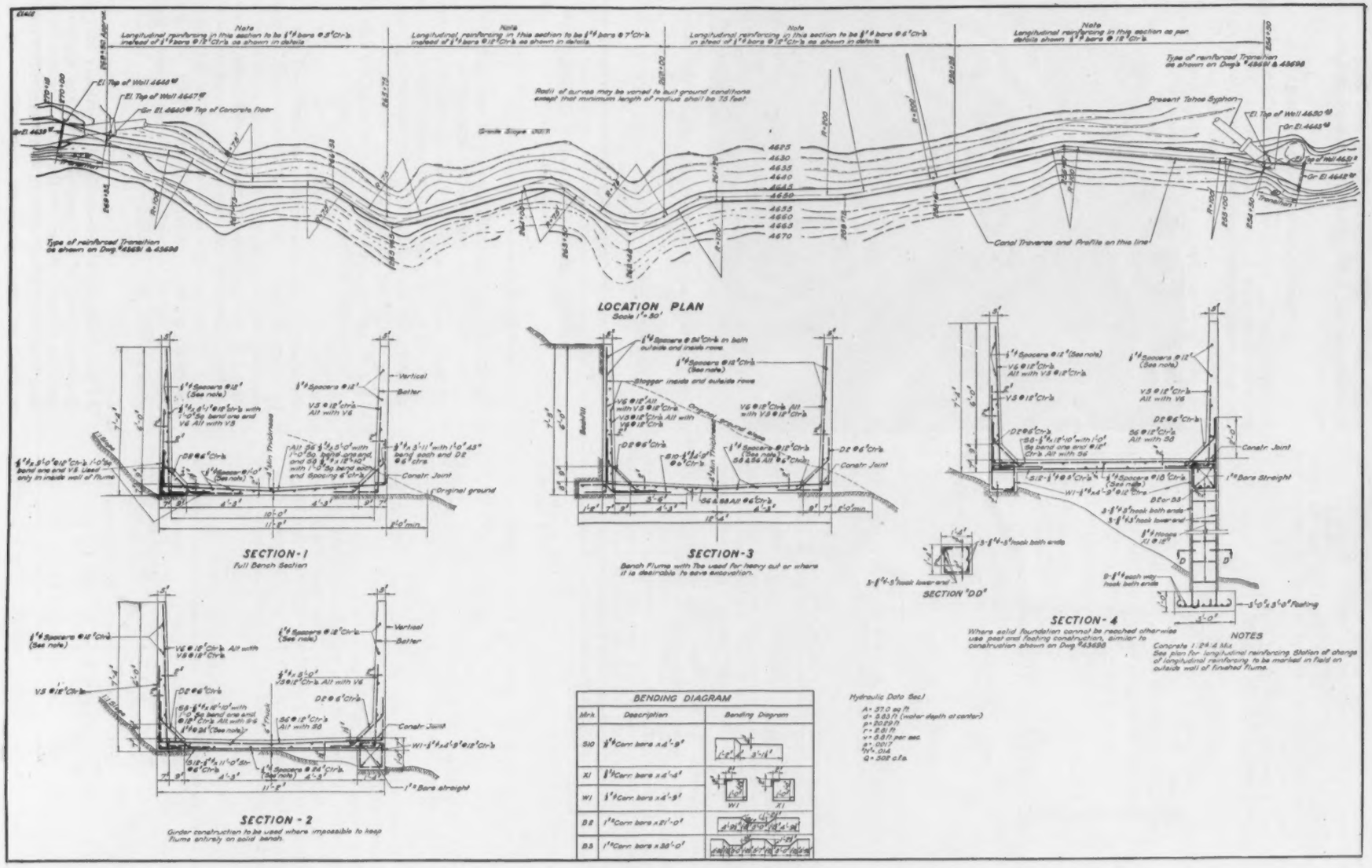
LOCATION PLAN
Scale 1"=50'
Note
Longitudinal reinforcing in this section to be ¾" bars @ 5" Ctr's instead of ¾" bars @ 7½" Ctr's as shown in details
Note
Longitudinal reinforcing in this section to be ¾" bars @ 7" Ctr's instead of ¾" bars @ 12" Ctr's as shown in details
Note
Longitudinal reinforcing in this section to be ¾" bars @ 6" Ctr's in sheet of ¾" bars @ 12" Ctr's as shown in details
Note
Longitudinal reinforcing in this section as per details shown ¾" bars @ 12" Ctr's
Radii of curves may be varied to suit ground conditions except that minimum length of radius shall be 75 feet
Present Tahoe Syphon
Type of reinforced Transition as shown on Dwgs #43691 & 43698
Canal Traverse and Profile on this line
SECTION-1
Full Bench Section
SECTION-2
Girder construction to be used where impossible to keep Flume entirely on solid bench.
SECTION-3
Bench Flume with Toe used for heavy cut or where it is desirable to save excavation.
SECTION-4
Where solid foundation cannot be reached otherwise use pad and footing construction, similar to construction shown on Dwg #43698
SECTION "DD"
NOTES
Concrete 1:2:4 Mix.
See plan for longitudinal reinforcing. Station of change of longitudinal reinforcing to be marked in field on outside wall of finished flume.
BENDING DIAGRAM
Mark
Description
Bending Diagram
S10
X1
W1
B2
B3
Hydraulic Data Sec.
A= 37.0 sq ft
d= 3.83 ft (water depth at center)
p= 20.29 ft
r= 2.01 ft
v= 2.81 ft per sec.
n= .0017
f= .014
Q= 302 c.f.s.

Fig 13. Plan and details for Tahoe Forest Reserve crossing, Drum canal enlargement, Pacific Gas and Electric Company.

All cement and sand, reinforcing rods and wire, delivered and distributed along the line of flume on the bench.

Gasoline and oil for the compressors.

Air compressors to be located at the foot of the hill, the necessary air pipe line to run from the compressors up the hill and along the bench.

Construct side forms for 350 lin.ft. of flume.

Supply any necessary stakes and bracing.

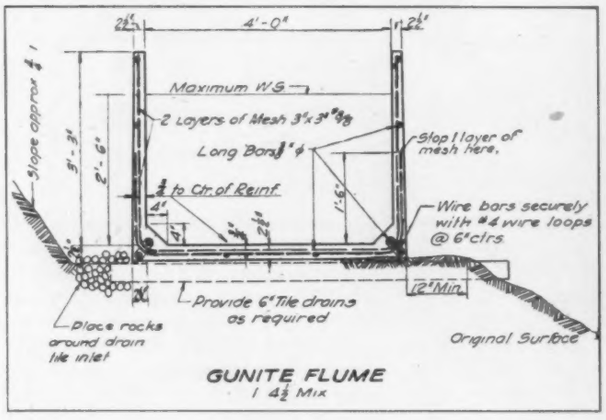
4'-0"
Maximum W.S.
2 Layers of Mesh 3"x3"#8
Long Bars #4
Stop 1 layer of mesh here.
to Ctr. of Reinf.
Wire bars securely with #4 wire loops @ 6' ctrs
Provide 6" Tile drains as required
Place rocks around drain like inlet
Original Surface
GUNITE FLUME
1 4½ Mix

Fig. 14. Contsruction details of gunite flume, 1:4½ mix, Pacific Gas and Electric Company.

Supply all other materials that may be necessary.

Supply rolls for straightening metal at the foot of the hill.

Gasoline driven pump for supplying water.

Water in the ditch at the head of the flume line.

Cement gun and necessary material and water hose.

The contractors will furnish at their own cost and expense:

Necessary nozzles and liners and air driven water pump as auxiliary screen for mixing box.

Will take delivery of the reinforcing mesh at the foot of the hill and will straighten and cut and deliver to the flume.

Will furnish all labor to place all the reinforcing rods and reinforcing mesh, to place and handle all the forms, to place all the gunite and to do all the curing and cleaning up of the job, also to cure the side walls under burlap for at least ten days. The side wall and bottom of the flume to be kept continually wet down for at least ten days after applying gunite.

Will furnish blankets for all of its operators.

Will furnish all burlap necessary for proper curing of the sides.

Will furnish transportation for all of its operators and any miscellaneous equipment.

We will do all of the work as outlined at a unit price of $1.80 per lin.ft. of flume.

The contractor placed the forms, the reinforcing, consisting of a 3 x 3-in. wire mesh, and the gunite. The routine was as follows:

One hundred and fifty feet of forms were set, the reinforcing laid, after which the gunite was shot on, walls and floor slabs being placed at the same time. After a section had been shot, a metal screen was drawn along a guide nailed to the top of the forms. This took away uneven spots along the wall and formed the fillet at the base of the walls. The next day the forms were removed and a flash coat of gunite sprayed on the surface to cover any rough spots. The walls were then cured for several days by means of wet burlaps hung over them and kept soaked with water.

TABLE II—Unit Costs

Operation	Labor	Material	Total	Unit Cost
Clearing 1.025 acres.....	211.10	None	211.10	206.00 per acre
Excavating 1,300 cu. yd...	1,544.45	50.75	1,595.20	1.23 per cu. yd. 0.78 per ft. bench 0.037 per L. ft.
Surfacing 2,031 feet.....	74.90	None	74.90	
Hauling, spotting material and building forms.....	899.10	539.92	1,439.02	0.71 per ft. flume
Placing forms	Misc.			
Cutting and placing reinf.	Material	3,106.92	.....	Mat. 1.53 do
Shooting gunite.....	Contract.	2,772.60	5,879.52	Cont. 1.36 do
Operating compressor and laying air and water lines	251.29	20.40	271.69	1.34 do
Eng. Sup. and miscel.....	652.50	.....	652.50	.....
Total Cost of 2,031 ft.....	3,633.34	6,490.59	10,123.93	5.00 per lin. ft. flume

GUNITING TIME AVERAGES

22 days total time contractor on job, equal to 92.5 ft. per day or 8.2 cu.yd. per day.

18 days actual shooting time, equal to 112.7 ft. per day or 10 cu.yd. per day.

Fig. 15. Gunite flume, Cross-over canal, Pacific Gas and Electric Company.

Report of Southern California Edison Company on Distribution of Materials and Construction Methods

1. *General Plant Layout*—

   (*a*) Flumes are generally located in remote regions and tent camps are required for housing the men.

   (*b*) Tent used as office for foreman, timekeeper and material man (latter two jobs usually done by one man). Portable blacksmith shop for sharpening steel and general work is the only shop required.

   (*c*) Jobs are too small for extensive plant for fabrication or erection of flume on our system.

2. *Receipt and Storage of Materials*—
   Materials are all checked at rail head and are hauled by truck to flume site where storage yard is made if necessary for sorting and segregating such material as steel and wooden flume supports, metal flume sheets and lumber. Generally all material is stored as near the flume site as possible and distributed on the initial delivery as much as nature of the terrain will permit; cement is stored in existing buildings, or in tents or in open, covered with canvas.

3. *Excavation*—
   As our flume work has consisted practically entirely in the replacement of old wooden flumes and syphons with metal or concrete flumes on the same location, there has been little excavation required. This excavation consisted of slight changes in grade and alignment and the excava-

tion for piers and bent footings. This has been practically all done by hand with only a small amount of team work.

4. *Material Distribution Along Flume—*

(*a*) *Narrow Gage Railroads—Corral Creek Flume*—A narrow-gage track consisting of 12-lb. rails was laid on top forms. Ford engines with regular transmission and chain driven cast iron flange wheels were used at first to be replaced later with electric mine locomotives. Side-dump hopper cars were used with vertical sliding doors. As the haul did not exceed 1,500 ft., no trouble was experienced due to settling and compacting of concrete under vibration. In the tunnels where the haul exceeded one-half mile, it was found that the concrete was so compacted that an air jet had to be used to loosen and dump the concrete. Later, a type of bottom dump car was devised which allowed hauls over a mile to be made without experiencing any difficulty in unloading.

(*b*) *Other Means of Transportation*—As noted under subdivision 11, where roads exist materials are delivered along the flume on the initial delivery; otherwise materials are hauled by truck as far as roads permit and are then distributed by other means. On

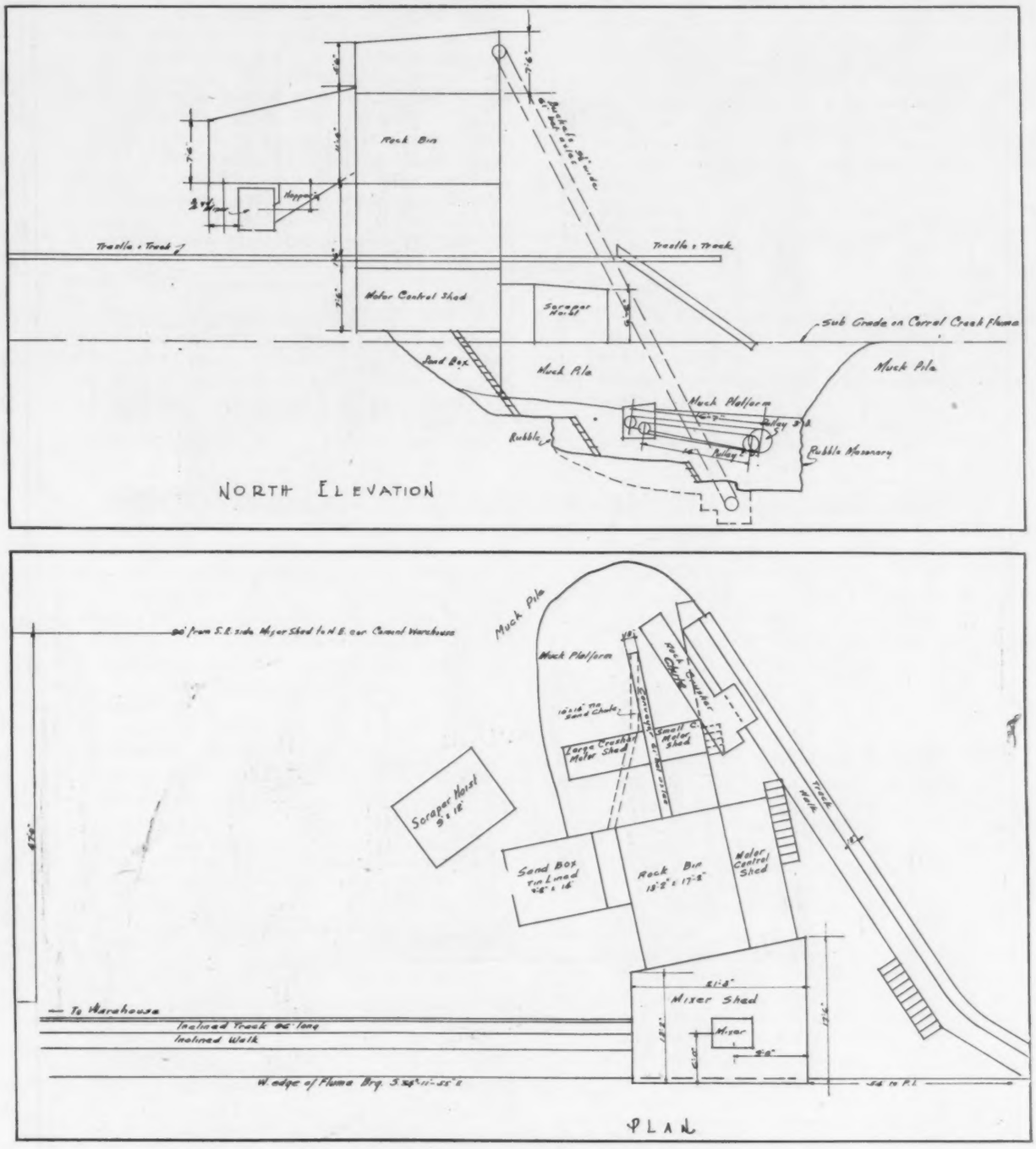

Fig. 16. Concrete plant, Camp No. 5, Southern California Edison Company.

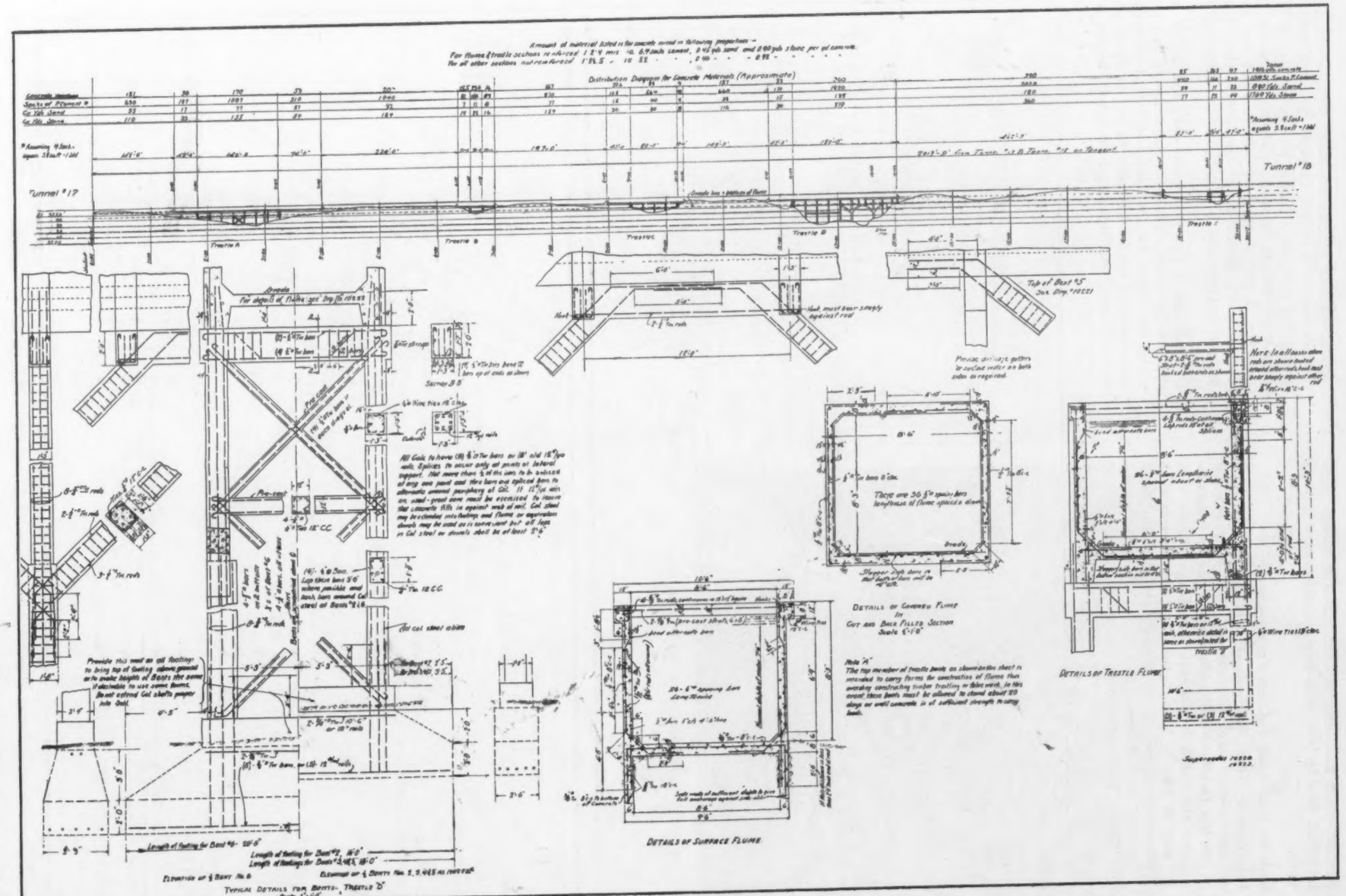

Fig. 17. Distribution diagram for materials; details for bents, trestle "D" and covered flume, Southern California Edison Company.

one conduit about six miles long made up mainly of tunnels connected by short sections of wooden flume where no means of access except a narrow trail existed, the flume materials were delivered by truck to both ends and were then distributed, using small trailer wagons on 14-in. wheels with a capacity of 2,000 lb., hauled by cut-down Fordson tractors operating through the tunnels and the wooden flumes before the latter were dismantled. On this same job gravel for concrete footings and for transitions from flume to tunnel was hoisted at two points from the river bed 200 to 400 ft. below the flume bench, using cableways operated by small gasoline driven hoists. Considerable material was also packed by mules and burros on this job due to the necessity of getting as much work done as possible before turning the water out of the flume and in order to cut the shutdown of the power plant to as short a time as possible. The Fordsons worked out very satisfactorily for hauling through the tunnels and the job was completed in scheduled time.

On another job in similar country where there was not sufficient room for truck operation, a small tractor was used to haul material along the flume bench on an orchard wagon or a sled. On a portion of this job a cableway about 500-ft. long operated by gasoline hoist was used to hoist all materials to the flume bench from which point distribution was made similarly to above.

5. *Central Concrete Plant—*

The concrete plant at Corral Creek was located on the tunnel dump, adjacent to the flume line and was used for concreting the adjacent tunnels as well as the flume. Rock from the tunnel dump was crushed to a maximum size of 1½ in. in jaw crushers and elevated to rock bin. Sand was obtained from the river and hauled a distance of two miles in dump trucks, unloaded into bin, and hoisted to hopper in rock bin.

Concrete was mixed in ¾-yd. mixers in shed located above and to one side of track on flume. Four cars constituted a train and sidings were installed and several trains used to keep mixer running continuously while concrete was being poured.

6. *Forms—*

(*a*) *Corral Creek*—Wood bents were erected to support track. These were independent of flume forms in order that vibration should not affect concrete settings. Metal forms in small panels were used for lining tunnels and, as there was only a short length of flume, it was decided to use these for flumes also. They were not satisfactory, as the small sized panels proved uneconomical to handle.

On account of their weight, it was found impractical to handle the interior forms and they were supported on small precast concrete blocks, which were left in as part of the floor. Forms were coated with linseed oil each time they were used. A very smooth concrete surface was obtained.

(*b*) *Miscellaneous Flumes*—Wood panel forms, interior form suspended, have been used on several short length concrete flumes.

7. *Reinforcing—*

(*a*) *Corrall Creek*—Steel delivered to job unbent. Bending table with template and pins used. No record of costs available.

(*b*) *Miscellaneous Flumes*—No mesh reinforcing has been used in flume work.

Fig. 16 shows concrete plant layout and Fig. 17 details of construction for Corral Creek flume.

INDUCTIVE CO-ORDINATION COMMITTEE REPORT[2]

The personnel of the inductive co-ordination committee was divided into four subcommittees, each of which was provided, so far as possible, with representation from each company. The subjects assigned to these subcommittees comprised the program for the year. Reports and discussion of the subjects assigned constituted the programs of the committee at the Engineering Section group meetings.

THE subcommittee organization and program of the inductive co-ordination committee for 1929-30 follows:

1. *Inductive co-ordination—*

(*a*) Discussion of proceedings of national inductive co-ordination committee.

(*b*) Discussion of proceedings of the national joint development and research subcommittee.

(*c*) Discussion of the general situation respecting inductive co-ordination in this territory, including significant current cases, joint planning, operation of GO 52, effects of power apparatus design and application, etc.

2. *Power Company Communication Systems—*

(*a*) Discussion of general requirements and problems of power companies for general business and operating communication facilities; scope and application of available systems, viz: privately owned telephone and telegraph circuits, printer circuits, carrier and space radio channels, etc., and communication company owned leased and exchange circuits, etc.

(*b*) Survey and discussion of character and extent of privately owned systems, including general construction practices for line (wire and cable), protective and terminal equipment, signaling, phantoms, carrier channels, space radio, etc.

(*c*) Discussion of special equipment and methods, including development or application of devices for protection, signaling, amplifiers, etc., superimposed signal or control circuits, testing equipment (particularly for "hot" lines), new apparatus submitted by manufacturers. etc.

[2] H. S. Lane, Pacific Gas and Electric Company, chairman. F. B. Doolittle, Southern California Edison Company, vice-chairman.
Coast Counties Gas & Electric Company: F. D. Beardsley.
General Electric Company: O. A. Gustafson, J. F. Spease.
Great Western Power Company: G. H. Hagar, Arthur Scott.
Los Angeles Bureau of Power & Light: H. H. Cox, O. W. Holden.
Los Angeles Gas and Electric Corporation: C. B. Judson, E. R. Northmore.
Pacific Gas and Electric Company: C. C. Campbell, L. J. Corbett, R. R. Cowles.
Pacific Telephone & Telegraph Company: D. I. Cone, Stanley Rapp.
San Diego Consolidated Gas & Electric Company: K. B. Ayres, A. S. Glasgow.
San Joaquin Light & Power Corporation: H. N. Kalb.
Sierra Pacific Power Company: E. D. Brown.
Southern California Edison Company: R. B. Ashbrook, J. O. Binney, R. G. Boyles.
Southern California Telephone Company: G. E. Nott, M. A. Sawyer.
Southern Sierras Power Company: C. M. Lindsley, E. Y. Porter, H. J. Schomberg.
Westinghouse Electric & Manufacturing Company: A. W. Copley, W. F. Grimes.

(*d*) Discussion of operating methods: including operation, control and authority; routine for construction, maintenance, repairs, inspection, testing of lines and equipment, etc.; records; reliability of service; allocation of communication expense.

3. *Radio Co-ordination and Complaints*—

(*a*) Discussion of general methods, personnel organization, equipment, records, co-operation with other interests, training of service men, local and state laws and regulation, etc.

(*b*) Summary and classification of complaints, costs, etc.

(*c*) Discussion of specific cases, problems, equipment.

4. *Joint Subcommittee on Common Primary and Secondary Grounded Neutral*—

This subcommittee will continue its present program with its established personnel.

The committee organization and distribution of programs was effected early, so that the committee was able to take up the program outlined at the first meeting in September.

At this meeting the status of the representatives of the telephone companies, as associate members of the assocation and therefore fully accredited members of the committee, was made clear.

In connection with the report of the subcommittee on radio co-ordination and complaints, George H. Curtis, manager of the Pacific Radio Trades Association, addressed the committee, outlining the co-operative method of handling complaints in the San Francisco Bay area and the results obtained.

In connection with the discussion of the common grounded neutral, Major Bennion addressed the meeting. He outlined the progress of the joint D. and R. project committees and incidentally gave some interesting side lights on the work and aims of the national headquarters staff and relations with the communication interests.

At the Los Angeles meeting in January G. R. Walters of the Radio Trades Association of Southern California spoke on the operations of their interference department, the co-operation of the utilities, their plan of training service men, the effect of local ordinances, and the gratifying results obtained.

In general the discussion at the meetings followed quite closely the program outlined. Minutes of each meeting in comprehensive detail were distributed to all committee members. The attendance and interest shown by both committee members and visitors were quite gratifying.

METER COMMITTEE REPORTS[2]

*Application of 5-Ampere Meters to Modern Lighting Installations**

GREAT improvements have been brought about in watt-hour meter construction during the last few years. The older types of meters, for instance, had a considerable droop in the characteristic curve on loads greater than 100 per cent. This droop has been almost eliminated up to 250 per cent on the modern meter.

The number of appliances used in the average residence is gradually increasing and when a number of such appliances are connected at one time the ordinary 5-amp. meter used on residence loads is undoubtedly overloaded. At such times it is reasonable to suppose that the older types of meters will run slow.

In order to determine to what extent these meters register slow a test was conducted on a number of installations in the following way:

A total of 56 residence loads, each of which had 5-amp. meters, and major appliances of one kw. or over, were selected. A modern type meter, after being tested and adjusted correctly, was connected in series with the installed meter in such a way that one meter did not register the losses of the other meter. The installed meters were of various types. Both old and new meters were read at intervals over a period of eleven months from March, 1929, to February, 1930, and the readings of old and new meters compared.

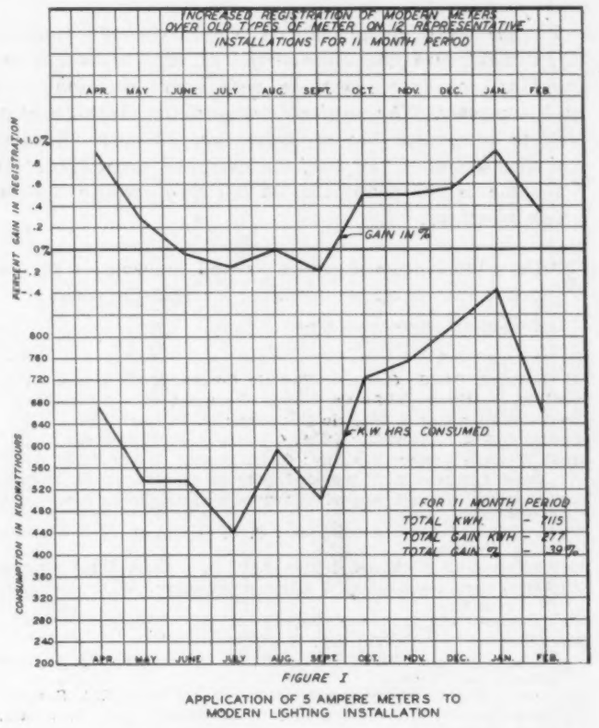
INCREASED REGISTRATION OF MODERN METERS OVER OLD TYPES OF METER ON 12 REPRESENTATIVE INSTALLATIONS FOR 11 MONTH PERIOD
APR MAY JUNE JULY AUG SEPT OCT NOV DEC JAN FEB
PERCENT GAIN IN REGISTRATION
GAIN IN %
CONSUMPTION IN KILOWATTHOURS
K.W HRS CONSUMED
FOR 11 MONTH PERIOD
TOTAL KWH - 7115
TOTAL GAIN KWH - 277
TOTAL GAIN % - 3.9%
FIGURE I
APPLICATION OF 5 AMPERE METERS TO MODERN LIGHTING INSTALLATION

Fig. 1. Application of 5-amp. meters to modern lighting installation

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[2] J. C. Abel, Pacific Gas and Electric Company, chairman. W. A. McMeekin, Los Angeles Gas and Electric Corporation, vice-chairman.

Coast Counties Gas & Electric Company: W. R. Van Bokkelen.
Duncan Electric Manufacturing Company: A. F. Blecksmith.
General Electric Company: Fred Garrison, W. C. Smith.
Great Western Power Company: W. G. Knight.
Leeds & Northrup Company: L. E. Emerich.
Los Angeles Bureau of Power & Light: J. C. Albert, L. H. Ellerman.
Los Angeles Gas and Electric Corporation: W. A. McMeekin.
Midland Counties Public Service Corporation: D. D. Smalley.
Pacific Gas and Electric Company: N. P. Carlsen, R. Crowell, E. M. Hart, E. L. Hughes, Otto A. Knopp, W. N. Lindblad, R. C. Seagren, G. H. Searle, L. D. Tycer.
San Diego Consolidated Gas & Electric Company: W. H. Talbott.
Sangamo Electric Company: J. G. Monahan, L. A. Nott.
San Joaquin Light & Power Corporation: G. A. Collins, C. F. Gilcrest.
Schweitzer & Conrad, Inc.: H. M. Thomas.
Southern California Edison Company: L. H. Beebe, L. L. Conrad, J. H. Dorsey, E. Ealson, W. R. Frampston, F. A. Redding, J. H. Vivian.
Southern Sierras Power Company: R. G. Jones.
Westinghouse Electric & Manufacturing Company: J. E. Bridges, W. F. Grimes.
Weston Electrical Instrument Corporation; J. H. Southard.

* Report of subcommittee on application of 5-amp. meters to modern lighting installations, meter committee, Engineering Section. W. N. Lindblad, chairman.

RESULTS OF TEST

(a) Total kw.-hr. (56 old meters)	27,263.8
(b) Total kw.-hr. (56 new meters)	27,312.2
(c) Total gain, kw.-hr. (new meters over old)	48.4
(d) Total gain in per cent	+ 0.18%
(e) Average gain per consumer per year—kw.hr.	94 kw.hr.

From the results it would seem that the actual average loss suffered, which might be corrected by installing a modern type of meter, is very small. The way in which this error varies with the season of the year is shown in Fig. 1. This curve is obtained from twelve representative meters which were read monthly.

*Current Transformer Meters**

The result of tests comparing the performance of the new 2.5-amp. meter and the 5-amp. meter for use with current transformers.

THE 2.5-amp. meter for use with current transformers is now available. A comparison, therefore, between it and the 5-amp. meter is desirable. One meter manufacturer definitely recommends its use in preference to the 5-amp. meter; two others will supply it but so far have not recommended its use.

To secure good accuracy on very light loads, the tests described herewith were made with a variable ratio current transformer. Two rotating standards were used, but temperature compensated and calibrated after potential had been applied several hours. Potential was off the standards only in the short interval in which readings were being recorded. By changing the series-parallel connections of the primary of the current transformer the rotating standards received 5 amp. at the 0.25, 0.5, 1.0, 1.25, 1.6667, 2.5, and 5.0 amp. points on the load curve of the meter under test. Therefore the load curve of the standards did not enter into the above points. With the current transformer connected 0.25 to 5.0 amp. (1 to 20) the curves were extended down to 0.05 amp.

The results recorded are the average of two meters of each make. Each meter was adjusted to give what was thought to be the best curve. The lower end of the curve can, of course, be changed by the light load adjustment. If the meter represented in Fig. 1 is adjusted to have a registration of 102 per cent at 0.05 amp. instead of 105.1 per cent, the curve has a pronounced dip between 0.1 amp. and 1.0 amp., reaching a low point at 0.25 amp. where the registration is 99.1. The meter in Fig. 2 differs from the other two in the effect of the light load adjustment on the lower end of the curve. If this meter is adjusted to 100 per cent at 0.05 amp. and at 2.5 amp. there is no point between where the registration is lower than 100 per cent. Fig. 3 shows the only one of three 2.5-amp. meters that has a satisfactory registration at 5 amp.

* Report of subcommittee on current transformer meters, meter committee, Engineering Section. G. A. Collins, chairman.

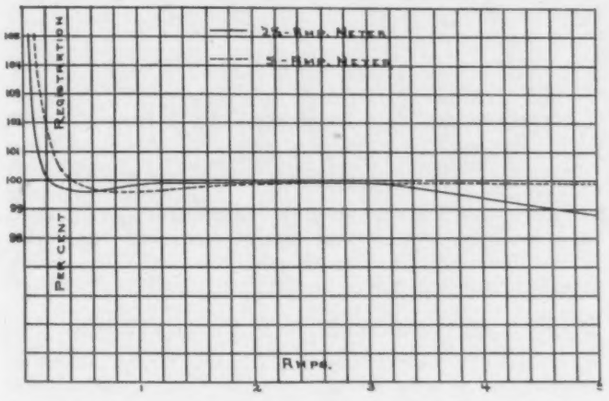

Fig. 1. Comparison of meters of manufacturer No. 1.

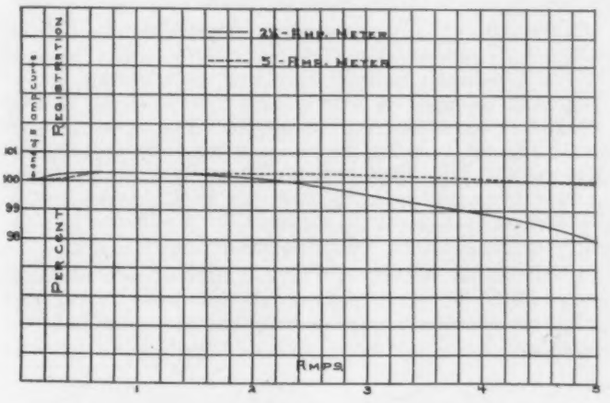

Fig. 2. Comparison of meters of manufacturer No. 2.

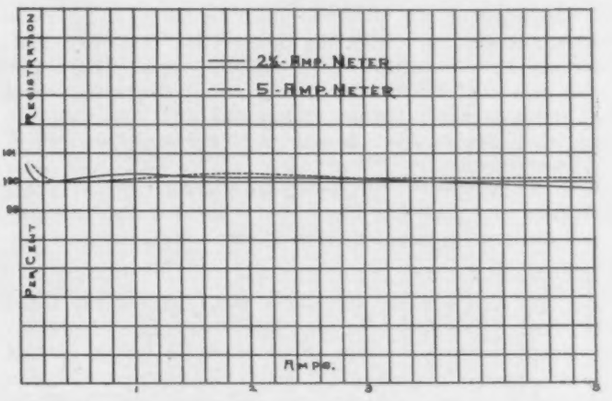

Fig. 3. Comparison of meters of manufacturer No. 3.

*Courses for Metermen**

An additional advanced course for those metermen who already have completed the two preliminary courses has this year been provided. Two schools were held, one in Berkeley, May 12 to 17, and one in Pasadena, March 24 to 29.

TWO courses for metermen have been fostered by the subcommittee on education of metermen this year. The first of these is the seventh annual short course for metermen which is to be held at Berkeley, May 12 to 17, inclusive. The work will be under the supervision of Prof. T. C. McFarland, assistant professor of electrical engineering. Those attending the course will be divided into three groups—"A", "B" and "C".

BERKELEY COURSE

"A" Group—

The work of the "A"group will consist of such subjects as fundamental units, electric circuits, magnetism and elec-

* Report of subcommittee on education of metermen, meter committee, Engineering Section. L. D. Tycer, chairman. W. A. McMeekin.

tro-magnetism, the induction principle, principles of alternating current, the theory of the induction meter and the study of electrical indicating instruments. This course is intended to supply training for the metermen who do our every day meter work.

"B" Group—

The work of the "B" group will be designed for more advanced metermen with the presumption that they shall already have completed the group "A" work. The course will consist of the following subjects: stroboscopic method of watthour meter testing, vectors and their application to metering problems, kva. measurement and its importance in connection with the recent rulings of the California State Railroad Commission, instrument transformers, checking connections and diagrams for primary installations, and general analysis of metering installations.

"C" Group—

A still more advanced course for metermen is being added this year. Heretofore the work has been carried as far as a study of the application of relays, which was a part of course covered by group "B". Group "C" this year will take up such subjects as: stroboscopic and other timing methods, vectors and their application to this line of work, kva. measurement, instrument transformers, induction principle, the single-phase meter, the theory of the induction relay and the application and testing of relays.

In addition to the above mentioned subjects under the various groupings, topics of general interest will be presented by specially qualified speakers. Among the subjects to be covered will be: application of vacuum tubes to light and power problems, electric rates, legal obligations of the metermen, moving pictures of the manufacture of indicating electrical instruments and oscillograph work.

Course for Southern California

The educational work carried on in southern California this year consists of a similar course conducted at the California Institute of Technology, Pasadena, March 24 to 29, inclusive. This course follows the same general outline as that given at Berkeley, with the exception that the relay work will probably be handled with the meter groupings.

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*Investigation and Tests on Various Forms of Relays**

A subcommittee of the meter committee has been studying the operating practices of member companies as regards relay testing and special investigations of various types of relays. To obtain comparative data a questionnaire was circulated and answers received from five different companies. Questions and answers appear in the following paragraphs.

IN order to obtain a comprehensive view of what was being done by the member companies in relay testing and in special investigations of various types of relays, the following questionnaire was sent out:

1. When the circuit breakers are aligned from east to west, and the relays on the board in the station are aligned from east to west, how do the relays line up with the circuit breakers? If a standard is maintained of A, B, C, is A the top, the left or some other place, or is there any consistent way of designating the relays on the switchboard?

2. What test facilities are you using to test the relays? How often are they routined, who routines them, and how complete is the test?

3. What has the company been doing in order to decrease the service interruptions caused by relay testmen and others working around the stations where the relay equipment is exposed?

4. Have you had any new relay problems this year or any new designs which would be of help to any of the other companies? Have you had any experience with the new condenser type potential transformers used with relays? Would you be interested in hearing a report on one of these installations?

5. If you have adopted any standards or standard wiring practice which materially aid in relay operation and relay application, we would be pleased to have you include that in your report.

The following answers which have been received will be of interest to all engaged in relay maintenance and relay testing:

San Joaquin Light & Power Corporation[1]

1. The standard practice on our system is for the three single-phase relays to be mounted in a vertical row. The secondary leads of each phase are identified by individual colors. Like colors are then mounted in corresponding positions for each switch.

2. Relay tests are performed with auxiliary testing transformers to obtain the required current. Part of the tests are made over-all, including both current transformers and relays, while part of the tests are secondary tests only. As yet no rigid testing schedule has been established. The routine tests are performed by substation inspectors.

3. Trouble of this character has been very infrequent as our practice is to remove switches from service before performing tests.

4. We have had no installations of the new condenser type potential transformer for use with relays. However, a report of operating experience on this equipment would be very interesting.

5. It has been made standard practice on our construction work to use cabled secondary leads with identified wiring for connections between current transformers and relays. This, we believe, facilitates proper connections and also reduces the possibilities of trouble in conduit runs which have occurred in that type of installation.

Los Angeles Department of Water & Power[2]

1. In all of our new stations, the panels having the relays mounted on them are built directly back of the benchboard which carries the O.C.B. controls. The relays are mounted on the panels in reference to the position of the O.C.B. controls on the bench board. They are mounted ABC, top to bottom, or left to right, facing the panels.

2. We have a relay test table in portable form, which is designed to make tests on all of our present types of relays. The relay testers also carry additional instruments to make other than the standard routine tests. Relays on the 110-kv. system are tested every three months. The relays on the 33-kv. system are tested every six months. All others are tested once a year. These tests are made by a special crew of men from the testing laboratories of this organization, under the direction of the relay engineer. All current, potential, trip, interlock and auxiliary circuits are tested.

3. Careful workmanship, rugged construction, selection and education of test personnel, have resulted in the reduction of unnecessary service interruptions to almost a negligible number.

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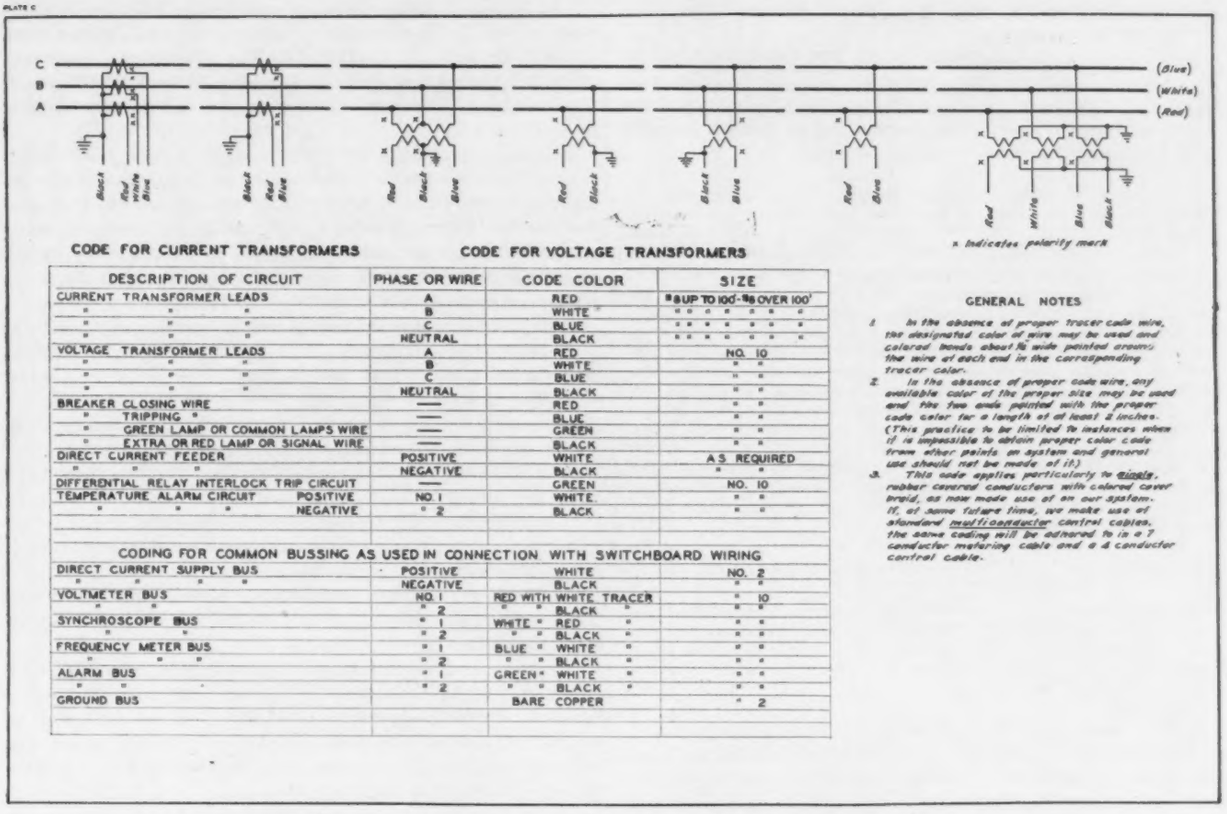
* Report of subcommittee on investigation and tests on various forms of relays, meter committee, Engineering Section. J. H. Vivian, chairman.

[1] Prepared by C. F. Gilcrest.

[2] Prepared by H. C. Gardett.



CODE FOR CURRENT TRANSFORMERS

CODE FOR VOLTAGE TRANSFORMERS

DESCRIPTION OF CIRCUIT	PHASE OR WIRE	CODE COLOR	SIZE
CURRENT TRANSFORMER LEADS	A	RED	#8 UP TO 100'-#6 OVER 100'
" " "	B	WHITE	" " " " " "
" " "	C	BLUE	" " " " " "
" " "	NEUTRAL	BLACK	" " " " " "
VOLTAGE TRANSFORMER LEADS	A	RED	NO. 10
" " "	B	WHITE	" "
" " "	C	BLUE	" "
" " "	NEUTRAL	BLACK	" "
BREAKER CLOSING WIRE	——	RED	" "
" TRIPPING "	——	BLUE	" "
" GREEN LAMP OR COMMON LAMPS WIRE	——	GREEN	" "
" EXTRA OR RED LAMP OR SIGNAL WIRE	——	BLACK	" "
DIRECT CURRENT FEEDER	POSITIVE	WHITE	AS REQUIRED
" " "	NEGATIVE	BLACK	" "
DIFFERENTIAL RELAY INTERLOCK TRIP CIRCUIT	——	GREEN	NO. 10
TEMPERATURE ALARM CIRCUIT POSITIVE	NO. 1	WHITE	" "
" " " NEGATIVE	" 2	BLACK	" "
CODING FOR COMMON BUSSING AS USED IN CONNECTION WITH SWITCHBOARD WIRING			
DIRECT CURRENT SUPPLY BUS	POSITIVE	WHITE	NO. 2
" " " "	NEGATIVE	BLACK	" "
VOLTMETER BUS	NO. 1	RED WITH WHITE TRACER	" 10
" "	" 2	" " BLACK "	" "
SYNCHROSCOPE BUS	" 1	WHITE " RED "	" "
" "	" 2	" " BLACK "	" "
FREQUENCY METER BUS	" 1	BLUE " WHITE "	" "
" " "	" 2	" " BLACK "	" "
ALARM BUS	" 1	GREEN " WHITE "	" "
" "	" 2	" " BLACK "	" "
GROUND BUS		BARE COPPER	" 2

GENERAL NOTES

1. In the absence of proper tracer code wire, the designated color of wire may be used and colored bands about ½" wide painted around the wire at each end in the corresponding tracer color.
2. In the absence of proper code wire, any available color of the proper size may be used and the two ends painted with the proper code color for a length of at least 2 inches. (This practice to be limited to instances when it is impossible to obtain proper color code from other points on system and general use should not be made of it.)
3. This code applies particularly to single rubber covered conductors with colored cover braid, as now made use of on our system. If, at some future time, we make use of standard multiconductor control cables, the same coding will be adhered to in a 7 conductor metering cable and a 4 conductor control cable.

Fig. 1. Standard code wiring system of The Southern Sierras Power Company.

4. Our relay problems of this year have been the same as in past years. We have had no experience with the new condenser type potential transformers used with relays and would be greatly interested in a report on them.

5. We have adopted a system of numbering all conduits, wires and sectionalizing test links, which aids materially in the operation, test, and maintenance of protective relay equipment.

The Southern Sierras Power Company[3]

1. We have a system of lettering the relays by marking them A. B. C. from left to right and top to bottom, when facing the relays, but we do not make any effort to align them in the same manner as the breakers are aligned, as there are cases where the breakers are aligned in this manner, but where the phases do not enter or leave all breakers in the same rotation.

2. We have bypass arrangements on all of our oil circuit breakers of 15 kv. and over and we make all of our tests by the over-all method. Our current values are all specified in primary amperes. We have a man who devotes his entire time to testing these breakers on an established routine and we have a card index system where we keep a record of all tests and relay operations.

3. We have made no special or unique provisions for any service interruptions caused by relay test men other than to have all of our jumpers and leads of a distinguishing color so that they may be easily seen from the ground.

4. We have several large relay installations coming up during the year but there is nothing in them which is not standard practice. We have had no experience with the condenser type transformer and have not seriously considered using any of them.

5. We have a standard wiring practice which is shown in Fig. 1.

San Diego Consolidated Gas & Electric Company[4]

1. Our company has attempted to standardize on system layout by naming the horizontal station busses A, B, C, from east to west and north to south and vertical station busses A, B, C, top to bottom, and by considering the positive phase sequence voltages A, B, C, to be rotating in the counter clockwise direction. When relays are mounted in a vertical line, phase A is on top, phase C is on the bottom. When relays are mounted in a horizontal line, phase A is on the left, phase C is on the right. No uniformity has been developed for installations where two relays are mounted in a horizontal line with the third relay placed below the other two.

2. Relay testing done on our system may be classified into two divisions, namely, monthly routine tests and calibration tests.

Monthly routine tests are made on all oil switches that have bypassing facilities. This includes generating station auxiliaries, distribution feeders, as well as 12, 33 and 60-kv. transmission line switches. The test is primarily a physical check and in the field is performed in co-operation with a representative from the switch maintenance force (electrical repair department) and relay maintenance force (electrical meter department). In the two generating stations the test is made by the station electrician. Relays are energized by applying potential to the terminals of their current transformers and the complete tripping and reclosing sequence is performed—in the case of automatic reclosing mechanisms, until lockout occurs. The few important switches that have no bypassing facilities are given a detailed check when occa-

[3] Prepared by R. G. Jones.

[4] Prepared by W. H. Talbott.

sion permits, usually after midnight in order to minimize discomfort to customers.

Calibration tests are made on all new equipment before it is placed in service and after every revision of relay settings. It is proposed to make check calibrations every two years, at least, in the future, but at present routine has not been developed thus far. These tests include:

(*a*) Attempt is made to adjust relays to operate correctly at theoretical settings obtained from standard curves. When this proves impossible, the time levers are set until a setting is found that will give the theoretical time desired. Complete secondary tests are then made which include minimum operating value and timing to 0.01 second for relay currents 100, 200, 500 and 1,000 per cent of setting. Contacts are examined, cleaned and adjusted, and the auxiliary seal-in device is checked for operation at 2.0 amp. d.c. for d.c. trip mechanisms. We have found that the trip contacts on a.c. trip mechanisms tend to cause excessive arcing, and considerable care is given to insure proper adjustment and seal-in. (*b*) Oil switch time is taken on both opening and closing to 0.01 second. (*c*) Current transformers are checked for polarity and ratio at 10 and 100 per cent rated current. (*d*) The control circuit test consists of tripping the switch by closing the relay contacts for all combinations to check circuits and determine possible feedbacks. This test also includes closing and opening the switch manually and by supervisory control.

The equipment used in these standard tests consists of:

Weston Ammeters, 0-2, 0-5/10, 0-50. General Electric cycle counter, Westinghouse cycle counter relay and a General Electric Type IRS single phase induction regulator. The instruments have been mounted on a special base and so arranged as to give a quick method of setting up for tests.

3. Only such tests that can be performed with safety and without interruption are executed, unless conditions are considered serious enough to warrant a complete shut-down. In such cases, the customers are notified and an agreement reached both as to time and duration of the outage.

4. Early this year it was deemed advisable to establish a scientific method of determining relay settings in order to obtain selective tripping and minimize service interruptions by obliterating false tripping. The solution of the problem was approached by determining fault currents to be expected at the various station busses and setting the relays both in current and time to give correct tripping.

To date we have had no experience with the condenser type potential transformer that you mention. However, we would be interested to hear of its successful application.

5. We have attempted to standardize on a control circuit color code but the work has not progressed far enough to warrant special mention.

Southern California Edison Company[6]

1. In our new construction we try to keep the control alignment similar to the switch rack. Our system rotation is C, B, A, counter clockwise. A is either the north or west bus, B the center and C either the south or east bus. The relays are mounted ABC, with A either the top or left and B the center. When two phase relays and one ground relay are used, the ground relay is either the center relay or is mounted below the other two.

Lead sheath control cable is used with brass markers on each end. Wires are all the same color.

Standard markings are used such as C_1, C_2, C_3, C_4 representing closing coil, trip circuit, light, and alarm, respectively. Other designations are used for special connections.

2. Each current transformer has its own short-circuiting switch with test links. Each tripping circuit has a knife switch to make the switch solid. Special knife switches are installed in conjunction with short-circuiting switches on differential hook-ups. This switch makes the relay solid before either of the short-circuiting switches involved can be opened.

The 220-kv. station relays are routined every three months, twice a year by the substation department and twice a year by the shop and test department. The substation department gives a tripping test only by applying current and tripping the breakers. The test division is notified if any trouble is experienced.

The regular routine tests are secondary only unless some trouble develops which looks suspicious and demands a more elaborate test. Differential current readings are always taken and power factor readings are taken on reverse power relays. Switches are actually tripped by means of switching load to other circuits wherever possible. By using the short circuiting switches and knife switches it is very seldom necessary to take equipment or lines out of service.

66-kv. relays and rotating equipment are tested every six months, all other relays once a year.

3. The first step along this line must be "education of relay testers." This is accomplished by keeping before them "good service" at all times. Special testing devices and special tools are required to help the men to keep from tripping the wrong circuits when testing relays.

It is also our policy to change wiring schemes if any sneak circuits develop or where interruptions are apt to be caused by various switching combinations.

The men are usually penalized to some extent if service interruptions are caused by carelessness on the part of men engaged in testing or maintenance.

4. We have installed at one of our 66-kv. transmission substations three Ohio Brass condenser type potential transformers. In order to make a comparative test on them as to their value as potential transformers we connected the three condenser type potential transformers in Y-Y and connected CR relays to their secondaries.

As the secondary volts are displaced 90 deg. from the line to ground volts in each transformer the proper phases were connected to give the same power factor readings as given on the CR relays.

The following power factor readings were taken with current I_A and a given potential from the standard potential transformers. See Fig. 2.

70 volts, 83+ Lag with burden of Weston power factor meter and Model 155 voltmeter.

70 volts, 83+ Lag with burden of above and 4 CR relays in parallel.

70 volts, 83+ Lag with burden of above and 3 CR relays in parallel.

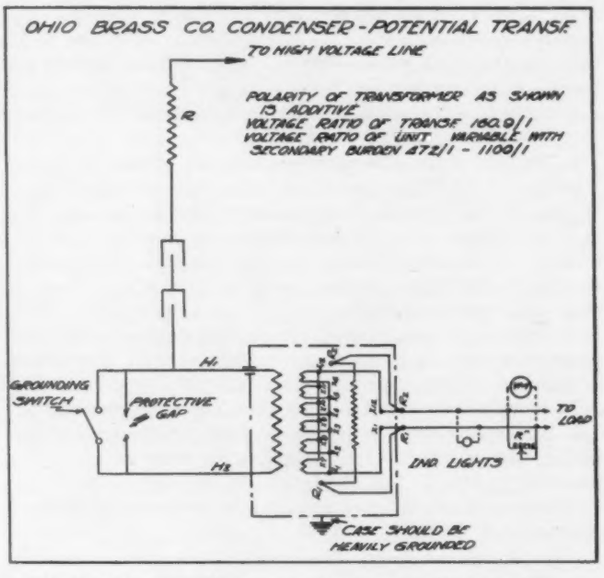


Fig. 2. Ohio Brass Company condenser-potential transformer.

[6] Prepared by J. H. Vivian.

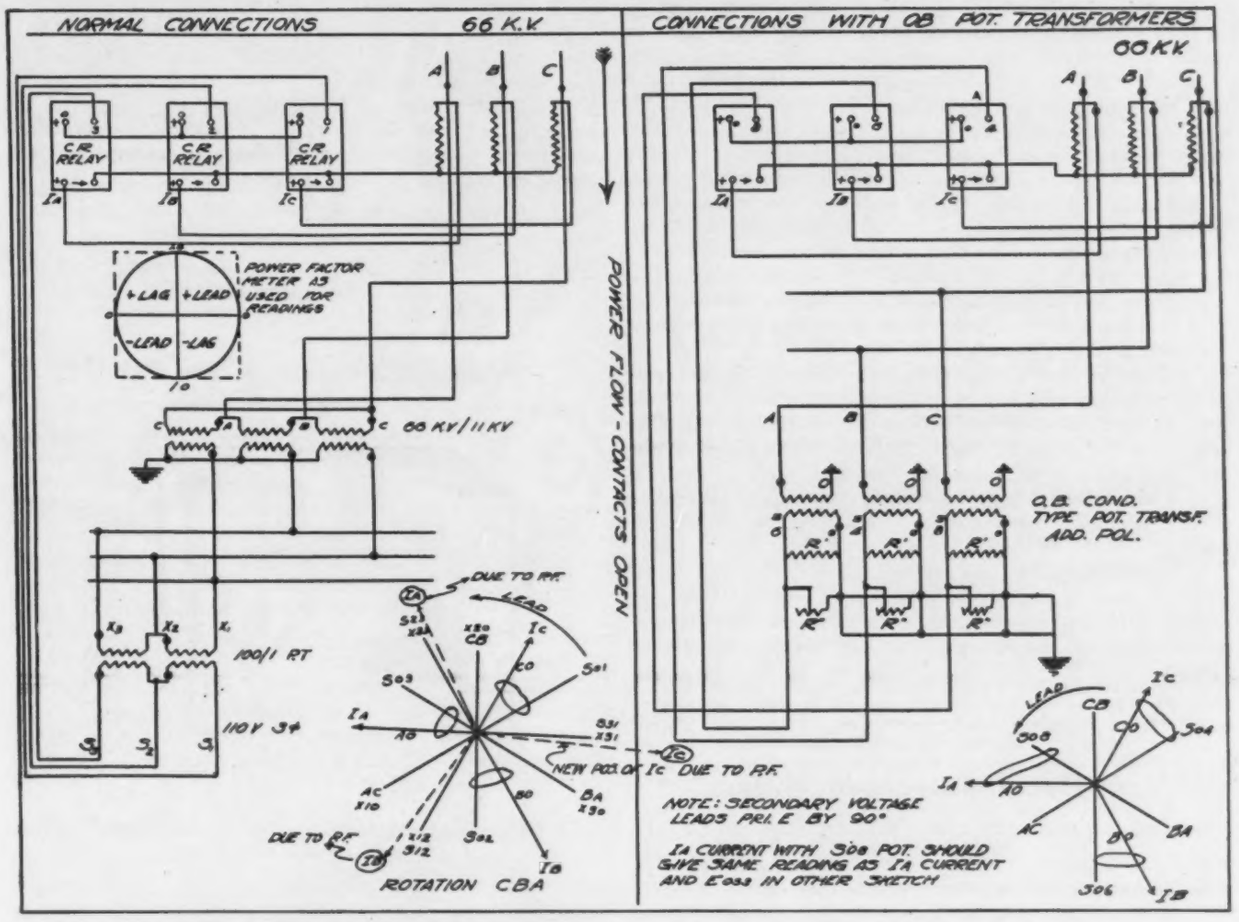

NORMAL CONNECTIONS 66 K.V.
CONNECTIONS WITH OB POT. TRANSFORMERS
66 K.V.
C.R. RELAY
POWER FACTOR METER AS USED FOR READINGS
+LAG +LEAD
-LEAD -LAG
POWER FLOW - CONTACTS OPEN
66 KV/11 KV
100/1 P.T.
110 V 3φ
DUE TO P.F.
LEAD
NEW POS. OF Ic DUE TO P.F.
ROTATION CBA
O.B. COND. TYPE POT. TRANSF. ADD. POL.
NOTE: SECONDARY VOLTAGE LEADS PRI. E BY 90°
IA CURRENT WITH 300 POT. SHOULD GIVE SAME READING AS IA CURRENT AND Eoss IN OTHER SKETCH

Fig. 3. Normal connections and connections with Ohio Brass Company potential transformer.

70 volts, 83+ Lag with burden of above and 2 CR relays in parallel.
70 volts, 83+ Lag with burden of above and 1 CR relay in parallel.

When the power factor readings were taken with the same current I_A and the same corresponding phase of potential from the Ohio Brass condenser potential transformers, the following results were obtained:

70 volts, 83+ Lag with burden of Weston power factor meter and Model 155 voltmeter.
30 volts, 0 left with burden of above and 4 CR relays in parallel.
35 volts, 17+ Lag with burden of above and 3 CR relays in parallel.
45 volts, 35+ Lag with burden of above and 2 CR relays in parallel.
63 volts, 50+ Lag with burden of above and 1 CR relay in parallel.

Readings and voltage would not change with R″ (see Fig. 3) disconnected when CR burdens were used. Burden of one CR relay is approximately 25 volt-amperes at 70 volts.

Only one phase is given above, but all phases were the same.

The above readings indicated that Weston CR relays cannot be used in this hook-up because this particular design of condenser type bushing transformer cannot hold up to ratio and phase angle.

The secondaries of the Ohio Brass bushing potential transformer were then connected in delta. The potential coils of from one to four General Electric IC5 ground directional relays were connected in the corner of the delta. The current circuit of the relays came from the secondaries to the current transformers in the 66-kv. line after they had been connected together to give the ground currents only.

As the current and potential values were 90 deg. out of phase at unity power factor ground fault conditions in the IC5 relay, the leads were phased so that the current led the voltage by 90 deg. This was to allow the relay to have a good torque under conditions of trouble when the power factor was lagging in the fault with respect to the source of power. The IC5 relay has a volt-ampere burden of approximately 35 volt-amperes.

The secondary voltage of each Ohio Brass transformer was found to be 120 volts without the R″ resistors in the circuit. With the high potential windings energized three-phase Y, the secondary voltages were exactly 120 deg. displaced. As the voltage was not too high and balanced, we attempted to close the delta first with a voltmeter only. The reading on the voltmeter, instead of being zero, measured between 80 volts and 240 volts (continuously swinging). Two of the transformers were arcing across their safety gaps while the delta was closed.

The R″ resistors were connected. This brought the voltage to 70 volts across each secondary. The delta was again closed by use of a voltmeter. By adjusting the R″ rheostats the voltmeter read between 25 and 40 volts (constant).

The R″ rheostat was adjusted so that the secondary voltage of each transformer was 57 volts. One IC5 relay was then connected in the corner of the delta and the voltage measured 15 volts across the relay. Three IC5 relays were connected in parallel, but 15 volts still remained across the potential coils.

The trip circuits of the IC5 relays are only connected to a light and bell. To date we have not had any trouble to cause the IC5 relays to operate.

We will report more information after the relays have had the opportunity of operating under fault conditions.

5. In order to keep protection on the 220-kv. lines at all times we have installed duplicate sets of relays at all 220-kv. stations. A bypass switch is provided for each set of relays.

Normally the current coils of both sets are in series, but either can be bypassed leaving the other set in service. Knife switches are provided so that either set can be made solid to either station bus as desired. To test the relays, one set is bypassed by opening the short-circuiting switch to it, and it is made solid to both busses by pulling the two knife switches in the trip leads (near the relay). The other set is still in service, giving full protection. When the secondary test is completed, one knife switch is closed. The oil switches are closed to both busses and one switch will trip out when the relay is closed. This switch is closed again and the knife switch opened. The other knife switch is closed and the switch to the second bus tripped, thus completing the test without at any time having the installation solid or out of service.

It is estimated that this method will save from 20 to 40 hours a year of unprotected operation at each station installed. It is not being used in 66-kv. relay installations as yet, because of the flexibility of our 66-kv. transmission system.

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*New Developments in Meters**

This report is made up of statements from the leading manufacturers as to new developments in meters and allied fields, which are here presented without comment.

General Electric Company

I-16 Meters—

IN order to round out completely the I-16 line and supersede completely the I-14 line of meters, a two-wire, 100-amp. I-16 meter has been put into production, having the same base as the 15 to 50-amp. meters.

D-15 Meters—

Three-element polyphase meters with I-16 elements were put into production this year in the 15, 25 and 50-amp. sizes. These meters are known as D-15.

Voltage Rating of Meters—

Nameplates are being changed to "115 to 120" and "230 to 240" volts rather than 115 and 230 volts. Meters are actually calibrated at 115 and 230 volts.

Protective Case for Meters Installed Out of Doors—

To facilitate metering in exposed locations, a waterproof protective case has been developed for use with single phase meters. The box is provided with conduit opening and sealing device.

Demand Meters—

The M-14 demand register replacing the M-10 device is in full production. A number of improvements have been added to increase the safety factors in performance and to make the device more rugged. The most important change is the doubling of the motor torque and the mounting of the reset weight on pivot bearings.

M-13 Demand Meters—

During the past year the M-11 demand meter has been considerably improved in operating characteristics and in the ruggedness of design and is now styled the M-13 meter. The chief improvement is in doubling the torque of the restoring coil and the provision of a cushioned armature stop to prevent chattering. Stroboscopic marks have been placed on the disk for timing purposes.

Inspection of Meter Jewels—

An interesting practical use of the cathode ray tube is that employed in the inspection of the meter jewels. Natural stones are separated from synthetic ones by passing the jewels under the rays of the cathode tube; synthetic jewels will not only fluoresce, but will remain phosphorescent after the excitation is removed, for some period. Natural jewels may fluoresce slightly, but will not phosphoresce at all.

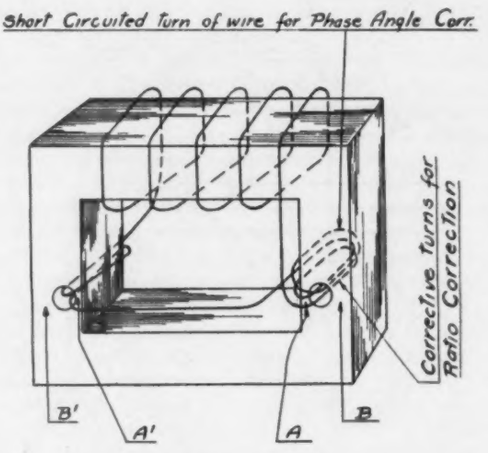

Fig. 1. Wilson method of compensation for current transformers, General Electric Company.

220-Kv. Metering Outfits—

Four single-phase, 60-cycle, 220-kv. metering outfits have recently been built for an eastern company and given 540,000 volts test. The windings are of the non-resonating type employing metallic shields. The tank is provided with a conservator.

Current Transformers—

The entire line of current transformers is being redesigned to make use of the Wilson method of compensation, the letter "F" designating this feature in the type letter. This scheme of compensation employs a few extra secondary turns and a short circuited turn threaded only through a portion of the core. It is shown in the accompanying picture. The extra turns are subtractive, the subtractive effect being greatest at light load with a consequent boosting of the secondary output.

Westinghouse Electric & Manufacturing Company

Switchboard Indicating Meters—

A complete line of indicating meters has been put into production. They may be mounted in containers, in which may be one, two or three meters placed either vertically or horizontally. The containers are attached to the back of the switchboard panel. The cover of the meters is of a single piece and mounted flush. These combination meters have illuminated dials which eliminate reflection and make a very neat appearance on the switchboard. Any combination of instruments can be supplied.

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* Report of subcommittee on new developments, meter committee, Engineering Section. Otto A. Knopp, chairman.

Covers for Switchboard Type Watthour Meters—

A new style of switchboard type watthour meter cover has been put into production. Instead of the standard single piece glass cover, a multi-piece oblong shape cover has been developed, similar to those furnished for the type "RI" kva. meter and the type "R" graphic meters.

Current Transformers—

A new current transformer, type K-5, has been developed which will replace the type "KO" for high grade metering. The accuracy of the type K-5 is much improved over former types, such as the "KO." These transformers will be supplied with a secondary terminal block and they will be interchangeable in mounting dimensions with the General Electric type WC-12.

A type "NB" which is a dry type indoor transformer will supersede the type "KB." This transformer will have a rating of 15,000 volts, 25 to 60 cycles and will have a capacity of 50 volt-amperes, compensated for 215 volt-amperes, 0.90 power factor. Its appearance and mechanical features will match the type "NA."

A type K-25 will supersede the type "KC." This transformer will have a rating of 25,000 volts, 25 to 60 cycles, 50 volt-amperes, compensated for 25 volt-amperes, 0.80 power factor. This type will be interchangeable in mounting dimensions with the General Electric type KC-109.

A portable multi-range current transformer has been put into production, for precision laboratory work. This transformer has 21 ranges. It is mounted in a walnut case with special selective dial switches, terminals, etc., mounted on a panel at the top of the case. The case has a cover so that all parts are enclosed when this is closed. Handles are placed

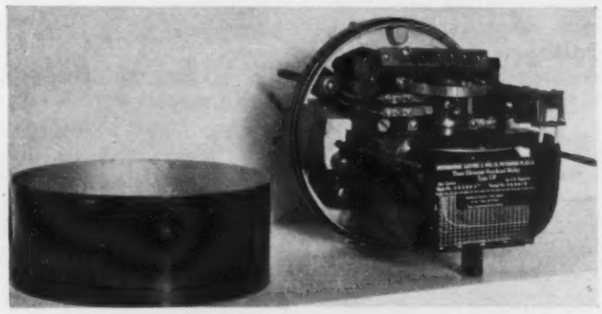

Fig. 2. CO relay, Westinghouse Electric & Manufacturing Company

on the side of the case so that the whole unit may be lifted with case. This unit has the finished appearance of a laboratory standard. The ranges run from 5/5 amp. to 500/5 amp. This transformer can be calibrated in itself by using the 5-amp. range either in connection with the Silsbee set or by connecting the primary in series with the secondary and determining the difference with a detector wattmeter.

CO Relay—

The CO relay has been completely redesigned, incorporating many mechanical and a few electrical changes. The more important changes are as follows:

1. The case of the relay consists of the base and removable metal ring, thus making all parts of the relay accessible and thereby making very easy assembly, inspection and repairs.
2. A new type of contactor switch in which the possibility of accidental closing of the contacts due to their being struck when replacing the glass cover, is eliminated.
3. A new shock-proof indicator, designed with a universal winding, which eliminates two styles of operation indicators previously used. The target falls by gravity when released by a latch which is operative as soon as the coil is energized.
4. A spring adjuster which permits an adjustment of the initial tension of the spiral spring, such that a tripping value of current approximately 15 per cent above or below any tap value may be secured.
5. An adjustment to the torque compensator which allows all relays to be calibrated to an engraved master curve for all relays.
6. New terminals built up of micarta plate. Removable studs are used so that for use on steel panels, the wiring may be fastened to the relay terminals by means of filister head screws.
7. Stationary contacts have been made more accessible and a decrease in the width of the time scale is an added feature.
8. A longer and better connector block.

Nearly all the features mentioned above are shown in Fig. 2.

Sangamo Electric Company

Type HC Meters—

The development of the type HC fully temperature compensated meter has been extended so that now the complete line has been included. The outstanding new features of these meters are:

Removable Terminals—The terminals are now removable and encased in a Bakelite moulding, and the designs have been made so that only two sets of terminals are required to accommodate any capacity single-phase and polyphase meter. For example, the 5 and 10-amp. single-phase, and 5 and 10-amp. two-element, three-wire single-phase have interchangeable terminals, while all the larger capacity single-phase and all the polyphase, both two-element and three-element, have interchangeable terminals.

For Use on Four-Wire, Three-Phase Systems—The two-element, three-wire single-phase HC meter has been developed in 5, 10, 15 and 25-amp. capacities with the dimensions of the terminal chambers corresponding to dimensions of the chambers of the single-phase single element of equal capacity. This is designed primarily for use on two phases of a four-wire, three-phase system and may not be used on the 110/220-volt, three-wire, single-phase installations.

Bottom Connected Polyphase—Both the two-element and three-element vertical polyphase meters are now built with the standardized bottom connected terminal arrangement, standardized both in dimensions and arrangement on all self-contained meters.

Potential Indicating Lights—Potential indicating lights can be supplied on any vertical type two-element or three-element bottom connected polyphase meters.

Upper Bearing—In the type HC upper bearing screw, a steel bearing is inserted and in addition the screw shank is recessed to provide a dust cap, which extends over the sleeve in the spindle. The upper end of this spindle is recessed also and accommodates the bearing proper and provides in addition an oil reservoir so that in position in the meter the tip of the steel bearing is in contact with the oil in the oil reservoir. This combination provides a noiseless and efficient upper bearing, a dust cap and a reservoir with a sufficient quantity of oil to last for a long period of time.

Instrument Transformers—

A short-circuiting device for current transformers has been designed and will be supplied as standard equipment on all current transformers, except the K-15. When the cover is removed, the secondary is short-circuited. See Fig. 3. The core clamps of the type K-30 transformer have been redesigned to accommodate this terminal arrangement and also to provide holes for pipe mounting and for general mounting, both in line with and at right angles to the primary leads.

Fig. 3. Current transformer, Sangamo Electric Company.

Outdoor Meter Box—

An outdoor meter box has been announced which will accommodate the standard type HC single-phase meter, providing a comparatively inexpensive, yet rugged, housing for those who desire to mount meters outdoors.

Type HB Register—

In the type HB maximum demand register a slight modification was made in the construction. A roller is now employed which rests on the resetting cams preventing wearing of the cam and requiring less power in operation. A helical spring is now used for resetting. In addition, a white pin has been included in the 40-tooth worm wheel, which meshes with the worm on the motor shaft to permit easy counting of the motor speed.

Stroboscopic Testing—

One hundred vision marks are stenciled on the top of the HC disks. These marks were placed on the disks for several reasons: first, to give a convenient division of the disk for calculation of percentage accuracy, for those who test meters in multiple; second, to provide a means for stroboscopic testing at full load and overloads, and third, for testing required magnet strength at the factory. The factory arrangement for stroboscopic testing is simple and comparatively inexpensive. Mounted immediately above the meter under test is an HC test meter with 100 slots cut in the disk in the corresponding position of the marks in the regular disk. A mirror, or prism, is mounted closely above the disk so that a beam of light can be thrown at right angles. A metal cover is used, a slot being cut in the bottom to permit the entrance of light rays, and right above and just to the front of the test meter is mounted a light. The light rays travel down to the disk of the meter under test and are reflected through the hole in the metal cover and then are reflected at right angles by the mirror, or prism, so that the operator standing directly in front can synchronize the meter under test with the slots in the test meter.

Duncan Electric Company

Potential Indicator for Polyphase Meters—

A mechanical device has been developed and put into production which indicates the presence of potential flux in any of the elements of a polyphase meter. It operates from the flux of the potential coil. When the coil is excited, a target can be plainly seen. When the potential is off or the coil open, the target will drop out of view.

Two-Element, Three-Wire Meter—

A two-element, three-wire meter has been developed for measuring accurately the power taken from two phases and neutral of a three-phase, four-wire system, or for measuring three-wire single-phase loads where bad unbalance exists. The element of this meter is the same as the Duncan MD polyphase, but the terminal chamber has the same dimensions and arrangement as the small MD single-phase meter.

Combination Meter—

The combination consisting of one 5-amp., 115-volt, two-wire, and one 25-amp., 230-volt, three-wire meter, in one case and under one cover, has been put into production for use in places where two meters are now used, one for light and one for ranges. Any combination may be had up to and including 25 amp.

Leeds & Northrup Company

New Type K-2 Potentiometer—

This instrument, Catalog No. 7552, is similar to the standard No. 7551 Type K potentiometer which has been manufactured for many years. It is provided, however, with an additional low range of 0/16 millivolts, making it suitable for temperature measurements with thermocouples. Its two other ranges cover 0/1.6 and 0/0.16 volts.

Of particular interest to metermen is a new feature simplifying the checking of wattmeters when both voltage and currents are to be read with the one potentiometer. A pair

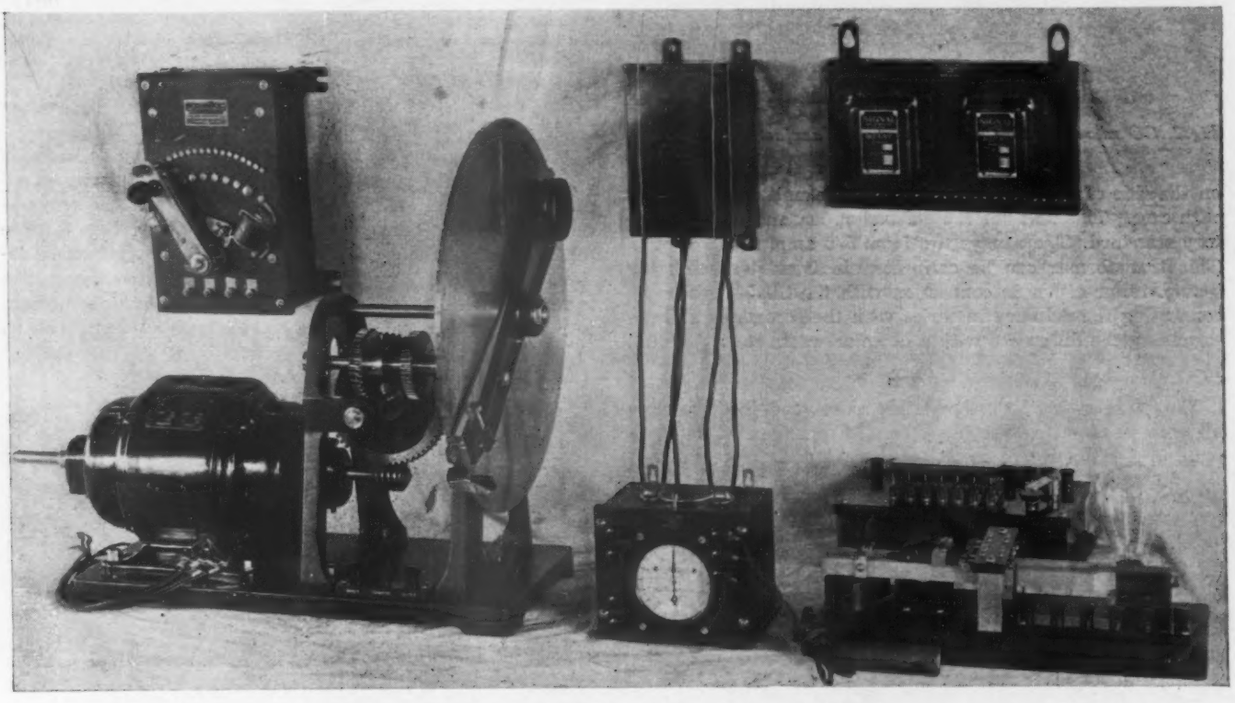

Fig. 4. Time interval apparatus, Leeds & Northrup Company.

of binding posts are provided, across which there is a constant drop of one volt. To these posts, through the customary volt box, is connected the load voltage. Through a suitable rheostat, this voltage is kept constant at such a value that a drop of one volt is obtained across the potentiometer terminals of the volt box. A four-pole double-throw external switch (or two double-pole double-throw switches) places the galvanometer and potentiometer in position for the current measurement or the voltage check. Since no adjustment of the potentiometer is necessary for the voltage check, virtually simultaneous voltage and current values are obtained.

"Watchdog" Potentiometer—

This instrument provides a means of maintaining accurately a constant voltage when checking wattmeters. The new type K-2 potentiometer described above, already includes such a feature, but the older design potentiometers do not.

The "Watchdog" potentiometer includes a standard cell dial and a rheostat for maintaining constant current in the potentiometer circuit. It is intended for use with the standard No. 7581 volt box, and has steps marked 100, 105, 110, 115, and 120 volts. Twice any of these values can also be used.

Lamp and Scale—

Coincident with the development of the new potentiometers, a new lamp and scale, No. 2100, has been produced, replacing the No. 2109 unit. The newer device differs from the older one in that it utilizes a four-volt lamp instead of a 110-volt lamp, and a new focusing arrangement provides simpler and more rapid adjustment of a clear cross-hair target.

Two-Stage Current Transformer Test Set—

Development has been almost completed of a portable instrument similar in appearance to the present No. 7150 Silsbee set, for checking the characteristics of two-stage current transformers.

Improved Rosa Curve Tracer—

An improved form of the well known Rosa curve tracer has been developed which permits very accurate and very rapid determination of complex wave forms at the highest frequencies.

Time Interval Apparatus—

This equipment is not new but has never been listed in the catalog before. Fig. 4 gives a good representation of the various items of the equipment. The purpose of the apparatus is to provide means for accurate timing in the laboratory.

In the left foreground of the picture is shown the time interval disk driven by the synchronous converter whose speed is controlled by the electrically driven tuning fork shown in the right foreground. The box shown in the upper left of the photograph is a combination starting box and field rheostat for the synchronous converter. In the center is shown a synchronous timer which is used to check the equipment and also for any general applications. It is provided with a specially designed hand-operated switch which controls a clutch meshing, with a minimum time delay, the rotating hand of the timer with its constantly rotating synchronous motor.

On the right-hand side of the photograph are shown two relays and a switch which serve to eliminate time lag errors when the time interval apparatus is used automatically to close and open potential circuits of rotating standards. This is accomplished as follows:

At the start of the test, relay No. 1 is closed and relay No. 2 is open. When the starting contact on the rotating disk closes, relay No. 1 opens, relay No. 2 closes, at the same time closing the potential circuit, thus a time lag has been introduced equivalent to the time required for relay No. 1 to open and relay No. 2 to close. At this point the switch is manipulated, returning the relays to their original positions (i.e., relay No. 1 closed, relay No. 2 opened) without opening, however, the potential circuit.

When the stopping contact of the disk is made, relay No. 2 closes, relay No. 1 opens, at the same time opening the potential circuit. Thus in opening the potential circuit, a time lag has been introduced equivalent to the time for relay No. 2 to close and relay No. 1 to open, which you will observe is the same time lag introduced in closing the circuit.

Adjustable Burden—

This set of burdens, No. 7156, is intended for simulating operating burdens when checking current transformers in the laboratory. It provides 50 volt-amperes of resistance adjustable in steps of one volt-ampere and approximately 50 volt-amperes of inductance adjustable in steps of approximately one volt-ampere.

Multi-Range Shunt—

This shunt, Catalog No. 4390, is a low-current value combination shunt. It has seven ranges covering 7.5, 3, 1.5, 0.75, 0.3, 0.15 and 0.075 amperes.

Switchboard and Portable Frequency Indicators—

These instruments were developed to meet the demand for portable and switchboard instruments for frequency measurement having a high degree of accuracy. The switchboard type can be provided with ranges of 24 to 26, 48 to 52, or 58 to 62 cycles. The first range is guaranteed to better than 1/25 of a cycle, while the two second ranges are guaranteed accurate to better than 1/10 of a cycle.

The portable instrument resembles in appearance the portable potentiometer pyrometers. It is usually provided with any of two of three ranges mentioned above. The accuracies are the same as outlined for the switchboard indicator.

The States Company

Switchboard Type Phase Sequence Indicator—

These phase sequence indicators have been designed for use on test tables where the determination of phase sequence is desirable. Besides giving the phase sequence, it gives evidence of whether or not the test table is alive. It is built for either 115 or 230 volts at 60 cycles, three phase.

The indicator consists of two resistances, a reactance and two carbon-filament pilot-lamps, one behind a red and the other behind a green bull's-eye lens. These elements are assembled on a substantial framework of metal which gives rigidity to the resistances and reactance and a cushioning to the lamp sockets so as to counteract effects of jarring. The over-all dimensions of the indicator proper are: height, 4½ in.; width, 4 in.; depth, 5½ in. Two mountings are made, one for fitting directly to the back of a panel, the other for clamping to some part of the pipe frame of a test table already in service.

The connections of the phase sequence indicator are such that when the phase rotation means that the current is lagging the voltage, the green (left-hand) lens is more brightly illuminated than the red one. On the other hand, a more brightly illuminated red lamp indicates a phase rotation such that the current leads the voltage. When the main switch of a test table is open, neither lens will be illuminated and this is an indication that the table is not alive.

100-Meter Capacity Portable Meter Rack—

This meter rack has been put into production to supply the urgent demand for a convenient way of transporting meters for test in the meter shop. Fig. 5 gives the construction of the rack on which the meters are hung by screws. A hook is provided for a tag to designate one rack from another. Racks are easily and quietly pushed about and can be made to turn within their own length.

These racks are light in weight, being built on the principle of reinforced angle-iron framework. The entire frame is rigidly braced against swaying and twisting when carrying

the full load of meters. The faces on which the meters are hung are ⅜-in. laminated wood covered with galvanized sheet iron. The screws for meter support are anchored in ½-in. furring strips on the back of each face. The platform is made of heavy hardwood giving low center of gravity to the rack. On the under side of this platform are two swivel and two fixed-direction wheels all on roller bearings. The wheel itself is made of canvas strips assembled and mounted

Fig. 5. 100-meter capacity portable meter rack, The States Company.

under hydraulic pressure. The assembly is such that biased edges form the rolling surface. In use it has been found nearly impossible to slide these wheels on a concrete, metal or wood surface, dry or wet.

Type KS AC Meter Testing Load Kit—

This load kit has been put into production to provide a light and rugged case in which is carried all testing equipment practically necessary for testing meters up to 25-amp. capacity at both full and light loads. There is provision in the kit for the particular standard for which it is ordered and space for leads and extra equipment.

This outfit includes a States Type S phantom load, thereby making use of a principle of loading which is efficient both in space and current consumption, also all leads. Output current control is by two carbon-pile rheostats and a full load/light load switch conveniently located on the top of the load. Meter connections are through flexible No. 10 and No. 14 leads 10 in. long with the exception of those from standard to load, which are 6 in. long. A click switch with amply long leads starts and stops the meter. The supply to the load may be either 115 or 230 volts, to which the load is adjusted by a SPDT toggle switch handily mounted on the load top. The case, of heavy fiber reinforced at the corners and edges, is 9 in. high, 14 in. long, and 8 in. wide.

Fused Terminals—

This new product affords an easy means for incorporating a fuse in a test circuit. This device has an insulated sleeve which is slipped over the wire and the solderless connection is made on the tip of the wire. The test cable is then drawn into the insulated sleeve, a fuse is dropped into the sleeve and the connector terminal screwed into the insulated sleeve. Various styles are provided.

Type "K" Ohmspun Load—

This new load has been designed to be used either in conjunction with a test kit or carried separately. The load is equipped with ohmspun non-inductive units, which are so mounted that the over-all dimensions are much less for a load of equal capacity. The case is aluminum which keeps the weight of the load down to 3¾ lb. This load is available in only one rating, 18 amp., 115 volts. The current steps are controlled by trigger switches and the current steps are as follows: ½, 1, 2, 5, 5, making available the following load values: ½, 1, 1½, 2, 2½, 3, 3½, 5, 5½, 6, 6½, 7, 7½, 8, 8½, 10, 10½, 11, 11½, 12, 12½, 13, 13½, 15, 15½, 16, 16½, 17, 17½, 18, 18½ amp.

ELECTRICAL FACILITIES, INC.

Heavy Current Three-Wire Phantom Loading Equipment—

In order to meet testing requirements of a Pacific Coast utility, a very flexible, heavy current, phantom load was designed and built for the over-all testing of large capacity, two and three-wire meters for both light and power on light and heavy loads. A small double-throw switch permits either addition or subtraction of the test load to or from the consumer's load without interfering with the latter. The equipment has also been found very useful and convenient for relay testing, and as a general all around test load. It is rated at 110 to 220 volts and 600 amp.

Referring to the accompanying picture, at the right is shown the phantom load transformer and at the left, one carbon rheostat for regulating the current. For three-wire testing two rheostats similar to the one shown are used.

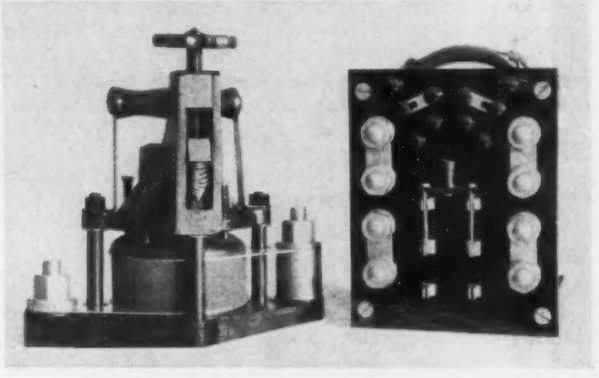

Fig. 6. Heavy current three-wire phantom loading equipment, Electric Facilities, Inc.

*Circuit Tester for Watthour Meters**

WHENEVER watthour meters are tested with a separate potential or by any method requiring connections or conditions which differ from normal line or service connections or conditions, there is always a possibility that some of the circuits within the meters are not completed after test. This is especially true of meters using potential circuit connectors or jumpers which have been stamped or pressed into shape. These often break at the place where they have been bent most sharply. When circuits are incomplete a meter may operate, but it cannot do so accurately. This not only represents a loss of revenue, but a real expense to check up or test and finally to replace with an accurate meter.

The meter test department of the Southern California Edison Company has developed a device for checking the circuits within the meters. This circuit tester has proved very satisfactory on both single and polyphase meters of several manufacturers. Fundamentally it is a low resistance telephone receiver in series with a low-voltage battery with the two end terminals arranged to be connected to the circuit in question, thus placing all three in series.

* Report of subcommittee on testing problems of watthour meters, meter committee, Engineering Section. F. A. Redding, chairman.

As finally completed, the tester is built from a medium size two-cell flashlight. The lens, lamp and reflector are removed and the flared front cut and bent into shape to hold a piece of 0.3-in. Bakelite radio panel. This piece is about 1.75-in. square, but is shaped to conform with the flare of the front piece of the flashlight case. On this are mounted two radio pin jacks for the telephone receiver cord tips and two spring brass wire prongs arranged adjustable to the terminals of

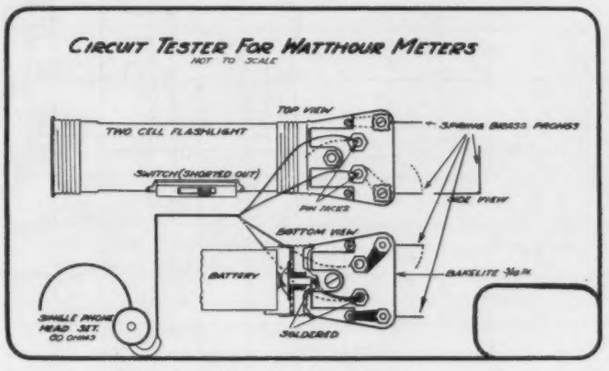

Fig. 1. Circuit tester for watthour meters.

the meters to be checked for open circuits. The telephone receiver is of the switchboard headset type of 60 ohms resistance which is about as much as will "click" in circuit with the high resistance potential coils used in some meters. The "click" indicates a complete circuit and should be heard when the circuit is first closed and again when it is opened.

The operation of the circuit tester is very simple and rapid. The wire headset band holds the telephone receiver against one ear, the flashlight case holds the battery and terminal prongs and requires only one hand, leaving the other free to arrange the meter so that the terminals are accessible. Only a light pressure of the prongs against the terminals is necessary.

With the exception of primary or separate potential type meters, a test made across the two load side terminals of a phase element or unit will give a complete circuit test of the entire element and its circuits within the meter case. The selection of terminals will depend upon the make and type of meter, but should always be on the load side, as this includes the series coil in the circuit test.

This circuit tester is not confined to watthour meters alone. It will be found very useful on other instruments and electrical circuits in general.

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*A Practical Magnet Testing Device**

THE relative strength of permanent magnets as used on induction type relays and watthour meters seems to have been quite a problem to all who have tested this type of instrument. When a magnet weakens in service the standard factory marking thereon is valuable only as a guide to replacing the weak magnet. But can this weak magnet be used on another instrument? What is its standard rating now? Or is it useless?

The magnet testing relay developed by the meter test department of the Southern California Edison Company has very satisfactorily solved these problems for them. It is so named because it relays to a cycle counter the time duration of one revolution of the relay disk. A strong magnet relays a longer time duration than a weaker one. The cycle counter is used because it can be controlled directly from a contactor in the relay, eliminating one source of personal error and making it possible to set up a very flexible set of curves from which standard markings may be read.

This relay was made up from a General Electric type M4 demand meter. The demand contacts and register, the magnets and mounting, and the disk and shaft were removed. A General Electric type I-14 disk and shaft, to which a contact controlling collar had been added, replaced the demand meter disk and shaft. Contacts to control the shaft counter were mounted above the disk and to the left of the shaft. The contacts and the controlling collar were so arranged that the cycle counter would be in operation during about five-sixths of one revolution of the disk. This period was accepted as one revolution when adjusting or using the relay. An auxiliary closed circuit push button was mounted above the disk and to the right of the shaft. This was so connected that the cycle counter does not come into operation until the button is pressed. Several stops were placed below the disk in such a manner that any magnet held firmly against them would be in about a normal position relative to the disk. For ease of adjustment a lever was attached to one of the pole shading pieces of the element and an adjusting screw brought through to the front of the relay. A series of stops were placed below the disk in such a position that any magnet held firmly against them would be in about a normal position relative to the disk. For ease of adjustment a lever was attached to one of the pole shading pieces of the element and an adjusting screw brought through to the front.

Although the M4 element is intended for 110-volt line service it was found desirable to operate this device at whatever voltage might result with the current regulated to 120 milliamp. On a 115-volt circuit with 120 milliamp., the voltage on the relay element is about 100. With the pole shading device adjustment is made so that the disk makes ten revolutions in 420 cycles.

Although the M4 element was intended to operate directly on 110-volt service, it was found desirable to operate the relay with a variable resistor in series, the current being regulated to 120 milliamperes. On a 115-volt circuit the voltage across the relay terminals was about 110 volts. With the current properly regulated, adjustment was made with the pole shading lever so that the relay disk made ten revolutions in 420 cycles. All adjustments were made with no magnet damping of the relay disk.

The drawing shows method of connection with Westinghouse cycle counter and gives data necessary for converting cycles counted into standard magnet markings as used by the General Electric and Westinghouse companies.

For example, a General Electric type I-14 magnet was placed in position against the stops of the relay. The disk speed was such that 357 cycles were counted during one revolution. Referring to the lower scale for I-14 magnets, start at left, add 300 to the scale and read up at 357. This point on the curve will read back to 17 on the vertical scale. As the number of cycles counted was between 340 and 440, we must add 300 to the scale reading of 17. The standard marking of this magnet is 317.

The performance of the relay has been checked over a period of several months. During this time quite a number of new and old magnets have been tested. When properly adjusted, the relay has verified the standard factory marking of practically every new magnet tested and has checked its own results within a very close margin. The "not good" limit of certain types of magnets was very carefully checked on the proper meters under normal test conditions and a margin for adjustment allowed. The magnet used in the

* Report of subcommittee on testing problems of watthour meters, meter committee, Engineering Section. F. A. Redding, chairman.

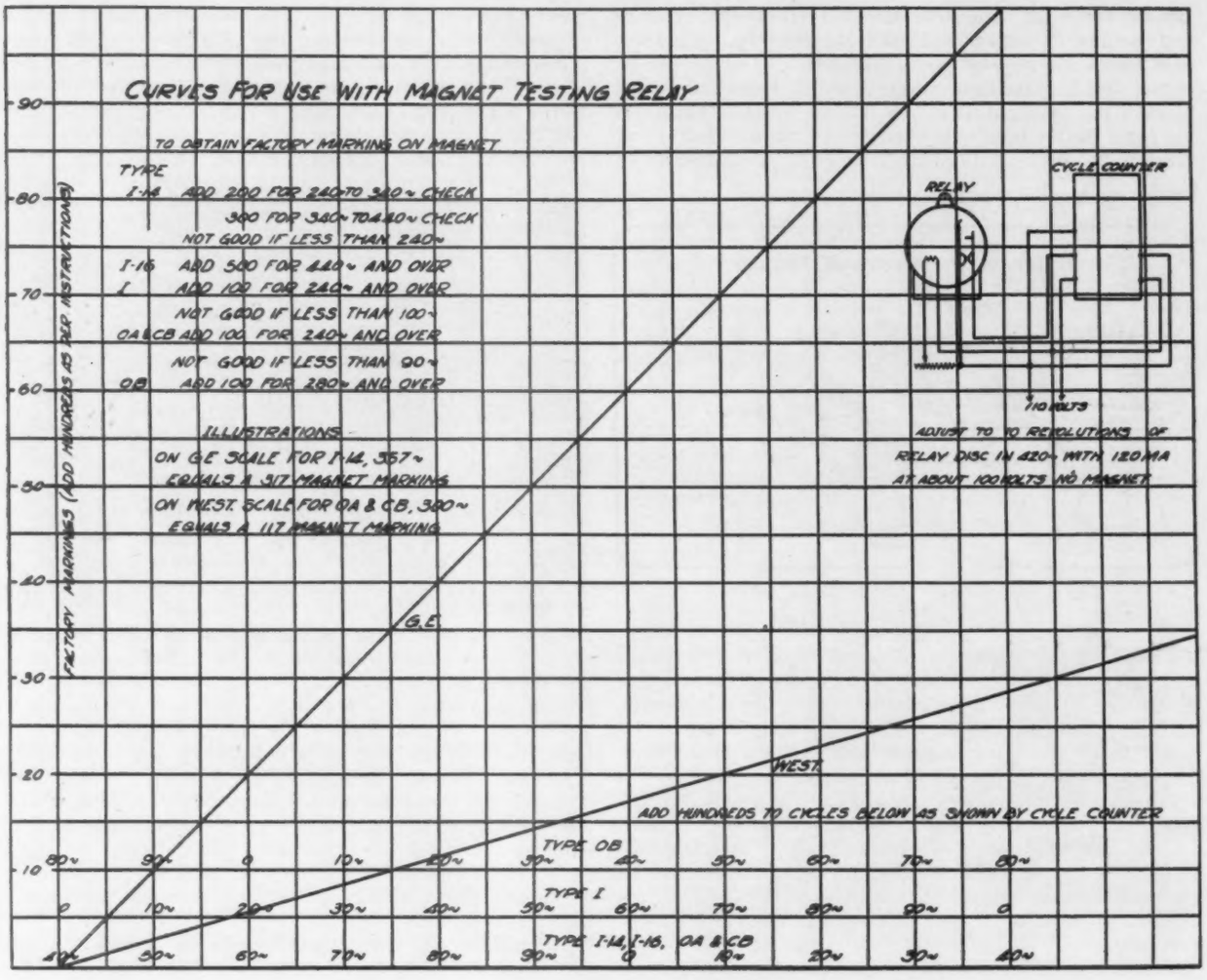
CURVES FOR USE WITH MAGNET TESTING RELAY
TO OBTAIN FACTORY MARKING ON MAGNET
TYPE
I-14 ADD 200 FOR 240 TO 340 ~ CHECK
300 FOR 340 ~ TO 440 ~ CHECK
NOT GOOD IF LESS THAN 240 ~
I-16 ADD 500 FOR 440 ~ AND OVER
I ADD 100 FOR 240 ~ AND OVER
NOT GOOD IF LESS THAN 100 ~
OA & CB ADD 100 FOR 240 ~ AND OVER
NOT GOOD IF LESS THAN 90 ~
OB ADD 100 FOR 280 ~ AND OVER
ILLUSTRATIONS
ON G.E. SCALE FOR I-14, 357 ~
EQUALS A 317 MAGNET MARKING
ON WEST. SCALE FOR OA & CB, 380 ~
EQUALS A 117 MAGNET MARKING
FACTORY MARKINGS (ADD HUNDREDS AS PER INSTRUCTIONS)
90
80
70
60
50
40
30
20
10
G.E.
WEST.
ADD HUNDREDS TO CYCLES BELOW AS SHOWN BY CYCLE COUNTER
TYPE OB
TYPE I
TYPE I-14, I-16, OA & CB
CYCLE COUNTER
RELAY
110 VOLTS
ADJUST TO 10 REVOLUTIONS OF
RELAY DISC IN 420 ~ WITH 120 MA
AT ABOUT 100 VOLTS NO MAGNET

Fig. 1. Curves for use with magnet testing relay.

example was found to be very consistent in results obtained and was therefore taken as a standard to verify the performance of the relay after all adjustments had been made. This final check will show up any friction, loose connections, or other troubles that may exist in either the relay, the cycle counter or the circuits.

OVERHEAD SYSTEMS COMMITTEE REPORTS[2]

THE report of the overhead systems committee for 1929-1930 includes data compiled by eight subcommittees on the following subjects:

Pole Line Structures and Devices.
Transformer Loading and Methods of Measuring.
Methods of Securing Satisfactory Grounds.
Corrosion of Metals.
Operating Records.
Joint Pole Practice and Construction Rules.
National Electrical Code Revision.
Conductor Vibration.

In addition to the work as contained in these reports we have a subcommittee working jointly with the inductive coordination committee on the subject of common primary and secondary nautral. Also we have several members who are working jointly with the Purchasing and Stores Section on the standardization of material for pole line construction.

The report of the subcommittee on pole line structures and devices will have additional data with which to make a supplementary report at a later date.

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*Conductor Vibration**

This report is made up principally of the experiences of some of the member companies of the Pacific Coast Electrical Association with conductor vibration and movement due to wind, short circuit stresses or other causes and the attempts that have been made to mini-

[2] See facing page for overhead systems committee personnel list.

* Report of subcommittee on conductor vibration, overhead systems committee, Engineering Section. H. H. Minor, chairman. N. P. Carlsen, Jr., S. L. Case, A. S. Glasgow, Walter Hayes, C. E. Heath, C. E. Ingalls, C. S. King, W. B. Loper, J. Mini, Jr., J. A. Mulkey, M. C. Richardson, A. L. Williams.

mize or eliminate such movement. In general the subject may be divided into the following three topics:

1. *Conductor vibration due to wind.*
2. *Conductor movement due to short circuit stresses.*
3. *Conductor movement due to ice or sleet unloading or other like causes.*

There follow papers relating the experiences of two of the Pacific Coast companies who have been most active in attempting to limit conductor breakage which has resulted from vibration. Comments on the subject by two of the wire manufacturing companies are also included as are some experiences of other operating companies.

VERY large sums are expended in the construction of overhead transmission and distribution lines. Their importance justifies this huge outlay and no item should be neglected in their design, the omission of which will result in a reduction of the effectiveness of the completed line. Damage to the conductors which may cause failure should certainly receive attention. Such damage may result from conductor vibration. It may very easily be overlooked until serious faults develop and then may be attributed to other causes. Construction and operating engineers should correct the conditions that cause such damage or limit the effect of those conditions.

Weakening the conductors due to vibration has been found quite prevalent on the lines of some of the Pacific Coast companies. Others report that no such trouble has been noted although general conditions such as wind exposure, type of construction, size and kind of conductor used, etc., are very similar. It may be that in reality broken strands have resulted from vibration but have not been detected or if noticed the failure has been attributed to other causes. It is felt that where strand breakage has occurred or where vibration is known to exist, as evidenced by visual inspection, noisy towers, loosened nuts, etc., it is safe practice to inspect the conductor closely at the first opportunity. Such inspection may reveal a hidden weakness that can be repaired in time to obviate a line failure and steps taken to make a recurrence of the trouble unlikely. The experiences which follow clearly illustrate the possibility of such damage and the fact that it may become quite serious before being detected or an incorrect determination of the cause may be made.

OVERHEAD SYSTEMS COMMITTEE

[2] F. E. Dellinger, Los Angeles Gas and Electric Corporation, chairman. J. O. Tobey, Pacific Gas and Electric Company, vice-chairman.
Aluminum Company of America: Walter Hayes, C. B. Judson.
City of Glendale: P. Diederich.
Coast Counties Gas & Electric Company: F. D. Beardsley, A. E. Strong, W. R. Van Bokkelen.
Electric Power Equipment Corporation: C. E. Ingalls.
General Cable Corporation: J. E. Crilly.
General Electric Company: J. C. Porter, W. C. Smith.
General Electric Supply Company: E. A. Hart, Max C. Richardson.
Graybar Electric Company: A. R. Fryklund.
Great Western Power Company: M. N. Clark, G. H. Hagar, C. S. King.
Hubbard Company: W. W. Glosser.
Joint Pole Association (Oakland): R. E. Hill.
Joint Pole Committee (Los Angeles): J. E. Macdonald.
K-P-F Electric Company: A. J. Pahl.
Line Materials Company: F. J. Gleiss.
Los Angeles Bureau of Power & Light: H. L. Caldwell, G. A. MacDonald, A. L. Williams.
Los Angeles Gas and Electric Corporation: C. B. Judson, E. R. Northmore, G. A. Riley, H. B. Wells.
Manufacturers' Agent: Ben C. Holst.
Ohio Brass Company: J. B. Naugle.
Pacific Gas and Electric Company: H. H. Buell, N. P. Carlsen, L. J. Corbett, R. R. Cowles, O. R. Evans, J. H. Fagg, A. M. Jeppesen, J. B. Madden, E. A. McGinty, Joseph Mini, J. B. Moorhead, L. B. Smith, T. W. Snell, J. O. Tobey, C. E. Young.
Pacific Telephone & Telegraph Company: D. I. Cone.
Railroad Commission: C. T. Mess.
San Diego Consolidated Gas & Electric Company: K. B. Ayres, A. S. Glasgow, C. L. Lawrie, R. M. Spencer.
San Joaquin Light & Power Corporation: E. R. Banks, R. V. Hall, H. H. Minor, J. A. Mulkey, D. D. Smalley, C. C. Wilson.
Southern California Telephone Company. G. E. Nott.
Southern California Edison Company: C. A. Bennett, J. O. Binney, W. E. Row, R. G. Boyles, F. E. Blausey, C. B. Carlson, W. P. Champion, J. F. Hodges, Harold Michener, E. R. Stauffacher, H. W. Tice.
Southern Sierras Power Company: W. B. Loper, E. Y. Porter, A. C. Putnam, H. J. Schomberg.
Taper Tube Pole Company: C. A. Duffie.
Westinghouse Electric & Manufacturing Company: C. A. Andrews, S. L. Case, C. C. Potts.

EXPERIENCES OF SOUTHERN CALIFORNIA EDISON COMPANY[1]

Any account of the experiences of the Southern California Edison Company with the phenomenon of conductor vibration necessitates a review in considerable detail of the results of experimentation and research which have been reported since 1923 in the technical press. If, therefore this paper should show details already familiar to those to whose attention it may come, it should be understood that the writers have intended it so for the sake of continuity and clearness.

Prior to 1923 this company had for ten years operated the greater part of the Big Creek lines at 150 kv. During this time it had been observed and was well known that the conductors on these lines vibrated a large part of the time. No serious trouble was ever laid to this phenomenon until after these lines were rebuilt for 220-kv. operation and also after the Eagle Bell 220-kv. lines were built. In each case the lines are two in number, parallel, on the same right of way and are constructed in horizontal configuration on steel towers. On the Big Creek lines 605,000-circ. mil ACSR is in use with fifty-four aluminum and seven steel strands, and is strung for a maximum tension of 6500 lb. The Eagle Bell lines were built using 666,000-circ.mil ACSR of stranding similar to the Big Creek cable and were strung for a maximum design tension of 13,000 lb.

A few reports had been turned in concerning broken strands at clamps on the Big Creek lines, but these were thought at the time to be due to improper clamping. On the Eagle Bell lines, however, vibration was observed to be particularly severe and after six months of otherwise satisfactory operation, one conductor parted at the outer end of a dead end clamp. Careful examination disclosed no reduction of area in the broken aluminum strands. For this reason vibration was suspected at once. No data on the steel core failure could be obtained by measurement or inspection as it had been burned. It is probable that the core had become heated as the aluminum area was reduced by breakage and that parting followed this heating.

Investigation following this failure disclosed broken aluminum strands at other dead ends, and also at suspension points. Obviously some method of preventing a recurrence would have to be found, as the line runs through a developed area with many transmission lines, telephone leads, highways and railway crossings under it.

The evidence presented by the failure was conclusive enough to indicate that vibration was the cause. An investigation was started immediately to determine the causes of these aluminum failures. Also an emergency remedy was devised and applied.

This emergency remedy provided an additional means for holding the conductor and also partially damped the vibrations before they reached the outer end of the dead end clamp. A second clamp was applied to the conductor at each end point with about one foot of conductor between it and the original clamp. This second clamp was attached by two strap links, one on each side of the same point to which the original clamp was attached, then an auxiliary jumper of conductor cable was bridged around the dead end clamp by attaching one end through a double grooved clamp to the

[1] Prepared by C. E. Heath and H. Michener.

span conductor beyond all dead end clamps, and the other end through a double grooved clamp to the original jumper loop. This gave a dead end assembly as shown in Fig. 1, and consisting of the following items:

1. A clamp holding the steel core only.
2. A clamp holding the composite cable as a whole and attached to the core clamp by short steel straps.

These two constitute the original dead end clamp and the jumper loop which led out between them.

3. Another clamp, the same as the second, bolted tightly onto the composite cable and attached by a strap link on each side to the same pin to which the forward end of the core clamp was attached. These strap links were put on with the clamp pushed back to take out lost motion but without applying any tension to the straps.
4. The double groove clamp to attach the auxiliary jumper to the span cable.
5. The double groove clamp to attach the auxiliary jumper to the main jumper loop.

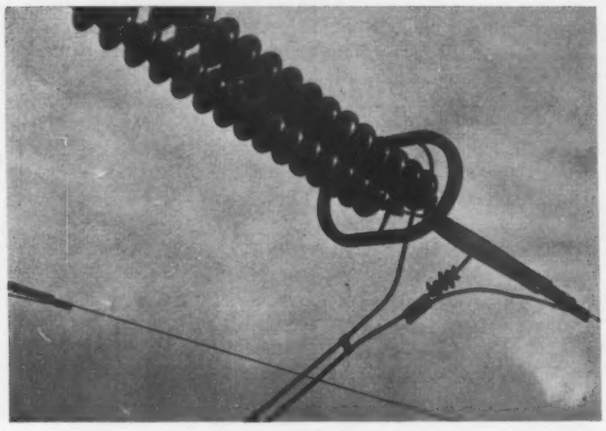

Fig. 1. Emergency protection against conductor failure at clamp, Eagle Bell 220-kv. line.

Several inspections during the year of operation with this device in use disclosed practically no further deterioration at the dead ends, and it has been noted that the conductor vibration in a span having one of these devices at one end is less than in a similar span supported in suspension clamps.

During the next two years the condition of the cable at all points of support received careful attention, and it was found that about 80 per cent of all these in exposed sections suffered some aluminum strand breakage. The number of these breaks varied from 1 to 40 strands at a clamp. Such breaks showed no reduction of area. Ground wire failures also occurred and inspection disclosed strands broken at the points of attachment in several places.

To correct the conductor trouble the cables on a considerable part of the west line were shifted approximately five feet to permit relocation of suspension clamps to new points on the cables. Wherever twenty or more strands were broken the cable was cut and a standard compression splice was made. Where fewer strands were broken, a bolted aluminum clamp was put over the break or the cable was wrapped with flat aluminum armor wire.

At first there was some difference of opinion as to the cause of the failures at clamps. Some thought the trouble due to the bending caused by vibration in the conductor, others thought it was due to bending caused by the changes in conductor position due to temperature changes, still others believed the failures due to improper clamping and damage to the strands during erection. Of these views the last was eliminated as soon as it was possible to get a complete view of the extent of the damage. To test the second theory an exhaustive test was made on a short experimental span which put the cable through a large number of bends similar to those it would get in the line, with the temperature changes. This proved quite conclusively that temperature changes were not responsible for the failures.

Soon after the 1923 break which was mentioned above, detailed studies of vibration were begun in an effort to determine its cause and characteristics. The method used and progress to that time was described by J. M. Gaylord, in Vol. 43, Journal A. I. E. E., November 1924.

Previous to the beginning of this study, reports were received of vibrations possessing amplitudes of from ½ in. to 6 in. or more and one report credited the vibration with sufficient power to lift a heavy man and throw slack into a string of suspension insulators when the man was standing on the wire at the insulators. These reports were generally considered to be somewhat exaggerated as there were no data to prove them.

There were also various theories as to the cause of this vibration. One was that the different rates of expansion and contraction with changes of temperature of the aluminum and steel were responsible. In proof it was observed that the vibrations would start in the morning when the sun first struck the conductor and at other times of the day when clouds would suddenly put the conductors in shadow, or would allow the sun to fall on the conductors when they had previously been in cloud shadow. Everyone was agreed that there was no vibration in a heavy wind. Also nearly everyone who had noticed the vibrations at all was willing to say that he had seen the conductors vibrating when no wind was blowing.

The apparatus used in the studies of characteristics and causes of vibration consisted of a recorder with appropriately devised traveling pencil, timing apparatus and paraffined string attachment to the conductor. Frequency records were obtained by moving the chart by hand to stop-watch timing. Duration records were obtained through the use of a Bristol mechanical recorder. Simultaneous records of vibration and temperature were made to determine any possible interrelation. No such relation could be found.

A large number of spans were found which never vibrated while others were found subject to particularly severe vibration. Long spans appeared to be particularly susceptible.

Spans subject to vibration were observed under various conditions such as those of sudden temperature change, energized and unenergized, during the process of being energized and of being taken out of service. None of these conditions seemed to affect the phenomenon. Apparently it was mechanical and might affect any line the same as those operated at 220 kv.

These studies confirmed the general belief that the conductors vibrated only in a vertical plane. The maximum recorded amplitude was about one inch. Frequencies varied from 12 to 30 cycles per second and nodes were observed from 12 to 16 feet long. Subsequent records reported by Theodore Varney show frequencies from 5 to 52 cycles per second, nodes from 4 to 38 ft. in length, and amplitudes of from 1/52 in. to 1 in.

Simultaneous measurements of the vibrations of two conductors of the same span, one having a tension considerably less than the other, showed that these two conductors vibrated during the same periods of time, but that the one having the lesser tension vibrated with smaller amplitude and lower frequency than the other with the same wind velocity. Simultaneous records for the center and outside wires failed to show any difference between the vibrations in these two conductors.

It was observed that wherever line spans were sheltered from the wind or where the wind was moving parallel to the line, no vibration occurred. A breeze of two to three miles per hour would start a long wave in the conductor. As the wind velocity increased the amplitude of the vibration increased until at some higher velocity a new wave of

shorter length would appear. It was observed that a wave once formed, whether 10 or 30 ft. long, would persist when the velocity had decreased one-half.

It was concluded by these studies that the vibrations were caused by air currents, very slight currents being sufficient to start them and to maintain resonance. Subsequent research by the Aluminum Company of America and reported by Mr. Varney in Vols. 45 and 47, Journal A.I.E.E., give further proof of these conclusions.

Concurrently with Mr. Gaylord's work, tests were being made on two experimental spans at California Institute of Technology where a mechanical device was used to cause vibration. It was hoped in this way to test various methods proposed for its prevention. However, it was found that these mechanically generated vibrations were very different from those actually occurring on the transmission line.

Up to the time the above studies were started the trouble experienced had been only with dead ends. Accordingly a new dead end clamp was designed which possessed a minimum moment of inertia with the idea of reducing the relative movement between the outer end of the dead end and the cable. The Aluminum Company of America was working on a similar dead end at the same time and has now adopted it as a standard.

Tests on this new dead end were made on the experimental span at California Institute of Technology. A recording device was made which could be attached to the dead end clamp and to the conductor just outside of the clamp, and in this way a record of the relative movement was obtained. It was found that the compression dead end of the new type gave much less relative movement between the dead end and the cable than was the case when the old style bolted dead end was used. This was true before the shield ring and jumper loop were attached to the dead end assembly, but the difference was largely masked when the shield rings and jumpers were attached. The relative movement was much greater in the case of both dead ends after these additions.

After the breaks at the suspension clamps were found to be so general it was apparent that the troubles at the dead ends were only a small part of the story and that it was necessary either to design a suspension clamp which would prevent cable breakage or to devise some means of preventing the conductors from vibrating. It was decided to try both.

The design department set to work to design a suspension clamp that would allow as little bending of the cable at its entrance as possible and that would hold this minimum amount of bending to a radius of curvature sufficiently large to prevent destructive stresses.

The research department started experiments to determine the minimum radius of curvature about which the conductor could safely be bent a great number of times while being under line tension.

As a result of these experiments a minimum radius of 16 inches was determined upon and a clamp with this radius at the two ends was designed. The clamp is supported from pivot points immediately below the conductor and the design is such that the conductor rests on the 16-in. radius supporting surface at least one inch outside of the last point where the conductor is held between the two halves of the clamp. As the conductor rises and falls due to vibration or temperature change the point of contact between it and the clamp surface moves toward and away from the center of the clamp.

Use of this clamp has proved the advantage of the new design in other ways than in the prevention of vibration, but as a preventive it does not function on account of differences in vibration characteristics in the two spans each side of the clamp and because the inertia of the clamp is too high to permit response to the vibrations. Since the design of this clamp, it was observed while stringing the new Vincent 220-kv. line that the vibration of cables while still hung in the stringing sheaves was so severe as to cause considerable difficulty in the attachment of the suspension clamps. Cases of broken strands are on record which occurred while the conductor was supported in a sheave.

The most promising results have been obtained by G. H. Stockbridge, transmission engineer, who has been in close touch with the whole problem from the beginning. His plan was to devise a suitable method to prevent vibration from occurring. Others have worked along the line of preventing vibration from doing any harm.

Mr. Stockbridge's work shows that vibrations may occur in waves from eight to fifty feet in length, that the longer waves are caused by very slight air currents while currents of higher velocity form shorter waves. The angle at which the wind strikes the line also has an influence on wave length. It was Mr. Stockbridge's observation which led to the belief that winds caused line vibration. In places where the Big Creek line was exposed to the winds broken strands were very numerous. In places where trees protected the line from direct influence, the breaks were very few. In some places where trees or hills protected nearly all of the line but where certain sections—sometimes not more than one span in a place—were not protected, breaks would be found only in these unprotected places.

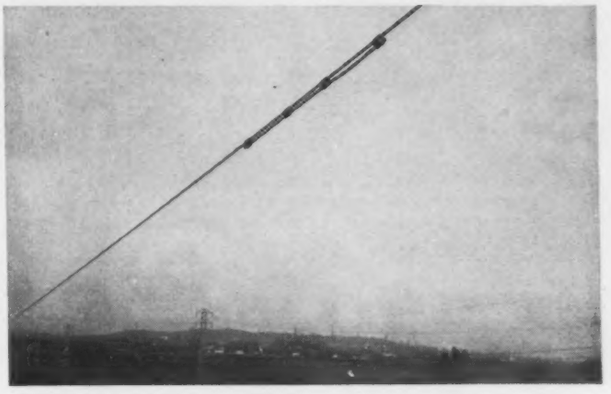

Fig. 2. Early damping device consisting of parallel length of conductor cable.

With this information, an attempt was made to stop vibration by breaking up the conductor symmetry. One span was lowered and a No. 4 solid aluminum wire was wound on it in a 6-ft. spiral for 300 ft. near the center of the span. This was found to reduce the vibration notably. If carried out for the full length of the span, the method might have proved effective, but this was considered impractical and the matter was dropped.

Next a 12-ft. length of cable of the same type as the conductor was clamped underneath the conductor with four parallel groove clamps at a point 30 ft. from the tower, as shown in Figure 2. This immediately stopped all short wave vibrations and reduced the long waves by about 50 per cent. It was quite apparent that the device contained an important principal, but there was some question as to just what the principal might be. To prove whether it was the stiffening effect, the cable was replaced with a section of ¾-in. pipe applied in the same manner, with the result that no benefit could be observed.

Mr. Stockbridge continued his work by studying the effects of weights clamped to the conductor. This showed that considerable good could be accomplished by using proper sized weights at proper locations. A 10-lb. weight clamped to the cable five feet from the support would reduce the length

of the last half wave in the span apparently by a length of cable, the weight of which was equal to the weight applied. Further, it reduced the amplitude in the last half wave. If the weight was increased beyond the weight of the conductor in a half wave, a new point of reflection was formed at the

Fig. 3. Stockbridge dampers in use on Big Creek 220-kv. line.

weight and vibration continued undiminished in the span. If the wave was always the same length in a span this method would prove fairly satisfactory with a weight of the proper size.

As operating conditions demanded that the line under observation be energized at all times except Sunday, considerable inconvenience was occasioned in making the tests. However, with the aid of cotton handlines the tests with distributed weights were continued. Using sacks filled with various weights of metal punchings pulled over the line at various distances from the points of support, it was found that with three 10-lb. sacks pulled up to the conductor with handlines and spaced 10 ft. apart, all visible cable vibration was arrested. Suspension of the same weights by cords gave the same results, but the clamping of 10-lb. lead weights directly to the cable resulted in no damping effect. Accordingly, the method of attachment was considered of prime importance.

Two 20-lb. sacks were rigged with double hooks to permit their being hooked on the conductor from the crossarm and the handline removed. These weights, one on each end of the same 100-ft. span, and hung 2 ft. away from the clamp, stopped all vibration permanently until the weights were removed.

As a result of all tests it was concluded that 10 or 15-lb. weights attached with properly flexible connections at approximately the midpoints of the shortest half waves next to the suspension clamps would prevent all visible vibration and thus eliminate all damage from vibration in any ACSR conductor in use on the system.

This fact led Mr. Stockbridge to design a damper consisting of a short length of flexible cable with either 5 or 7-lb. weights on each end and an attachment clamp in the center. Originally the cable used was a piece of conductor the same as that in the line to which the damper was attached. Concrete was used originally for the weights. A flat spring was tried out as a substitute for the cable but was found too sensitive for satisfactory use. The final adopted design is as shown in Fig. 3. The shape of the weights is such that the guy wire is sufficiently shielded to prevent the formation of corona. From one to three dampers are attached to each span, the number depending upon the severity of vibration in each span, which in turn depends upon the span length.

The Stockbridge damper has now been in use on the Big Creek and Eagle Bell lines for three years. The same type damper has been applied to all steel cable skylines. Trouble on these lines from this cause has been eliminated.

The new Vincent 220-kv. line constructed in 1926 and 1927 is equipped with the new type dead end and suspension clamps and with 7½-lb. Stockbridge dampers. Design data on all lines of the company where dampers have been attached are shown in the accompanying table.

It will be noted that no dampers have been provided on the Long Beach-Lighthipe line where 650,000-circ.mil bronze

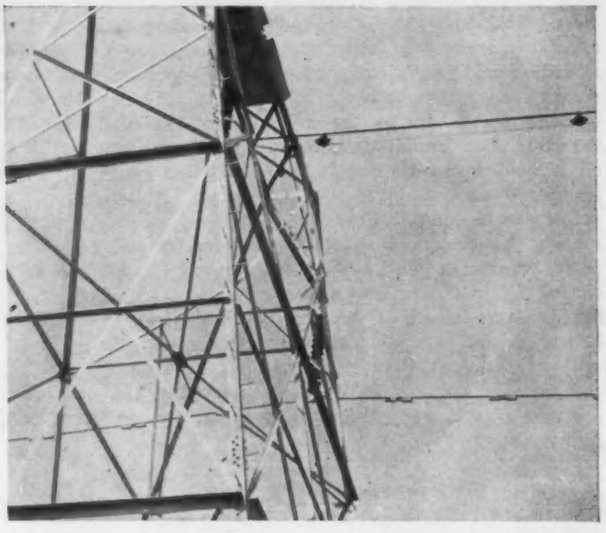

Fig. 4. Dampers consisting of wire-mesh container filled with metal punchings applied to one conductor on Vincent line. Note cantilever weight type on other conductors and on skyline.

copper conductor has been used and that the same is true of the No. 4/0 copper ground wire. Experience with copper conductors on steel tower lines over a period of twenty-three years of operation has failed to produce any conductor damage from vibration. For this reason it was decided to try the Long Beach-Lighthipe line for five years without dampers. However, the line is being carefully watched and if any trouble develops it will be equipped the same as the others. A few spans have been equipped with dampers for experimental purposes and are entirely satisfactory.

In continuing his studies, Mr. Stockbridge has applied the cantilever damper principle to smaller conductors and his experience so far indicates that this device is not sensitive to the higher frequencies existing on smaller cables. However, he has found that the application of the suspended weight principle through the use of a wire mesh container of proper design filled with metal punchings and properly located has a great deal to promise as a successful damper for small conductors. Fig. 4 shows this type damper on one conductor of a line with the cantilever type also shown.

The question has been raised from time to time as to the matter of "dancing" cables. The writers know of no place on the Southern California Edison Company's system where this phenomenon has occurred except as an accompaniment of unequal loading of sleet during or following storms. At such times trouble is experienced on lines of vertical configuration by lower conductors whipping into higher ones in the same plane, also from telephone lines whipping into transmission conductors. This experience has been confined

TABLE I—Characteristics—220-kv. Lines

Southern California Edison Company

Lines	Big Creek	Eagle Bell	Vincent	Long Beach Lighthipe	Lighthipe La Fresa
Constructed.....	1912-13	1923	1927-28	1928	1929
Configuration.....	horizontal	horizontal	horizontal	vertical	vertical
Circuits per tower..	1	1	1	2	2
Conductor					
Kind.....	ACSR	ACSR	ACSR	bronze copper	ACSR
Size circ. mil.....	605,000	666,600	1,033,500	650,000	666,600
Alum. stranding...	54x0.1059	54x0.1111	54x0.1384	42x0.1245 copper	54x0.1111
Core stranding....	7x0.1059	7x0.1111	7x0.1384	19x0.1245 bronze copper	7x0.1111
Composite diam...	0.953	1.000	1.246	1.12	1.000
Weight per foot...	0.779	0.857	1.33	2.92	0.857
Design tension....	6,500	13,040	12,000	13,300	8,000
Elastic limit composite.....	14,675	16,180	25,000	33,600	16,180
Dampers number..	1*	1*	1 to 3	none	1*
Dampers weight...	double, 5 lb.	double, 5 lb.	double, 7½ lb.	...	double, 5 lb.
Ground Wire, Kind.....	Siemens Martin	High Strength	Siemens Martin	MHD Copper	Hitenso B. B.
Size.....	½-in.	½-in.	½-in. & 5/16-in.	No. 4/0	No. 2/0
Stranding.....	7	7	7	7	7
Weight per foot...	0.520	0.520	0.52 & 0.65	0.653	0.411
Design tension....	5,500	8,000	5,500 & 7,000	4,000	4,000
Dampers—number.	1	1	1	...	...
Dampers—weight..	single, 5 lb.	single, 5 lb.	single, 5 lb.	none	...

*Occasional long spans equipped with two dampers each end.

Fig. 5. ½-in. steel strand reinforcement applied to 397,500 circ.-mil all-aluminum conductor. Vibration damped 25 per cent.

Fig. 6. Stockbridge 10-lb. damper applied to 366,400 circ.mil A.C. S.R. Installed 3 ft. 6 in. from clamp. Vibration damped 100 per cent.

to voltages lower than 220 kv., as the company has no vertical 220-kv. construction in sleet territory. Changes in the length of the middle arm to obtain an offset from the normal conductor plane have eliminated trouble from sleet loaded lines.

In conclusion it may be said: (1) that steel reinforced aluminum cable is a thoroughly safe and practical conductor when relieved of vibration hazards, (2) that the Stockbridge damper effectively eliminates vibration, (3) that there is nothing insidious about conductor vibration except the fact that the damage is usually done before the operating company becomes aware of it, (4) that when enough people become aware of the existence of an operating hazard from vibration of conductors, it will be eliminated in the same manner that has brought about the solution of other line design problems.

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[1] Prepared by J. A. Mulkey.

Conductor Vibration on the San Joaquin Light & Power Corporation System[2]

The first failure of stranded aluminum due to conductor vibration on the San Joaquin Light & Power Corporation system was noted in October, 1927, on the thirty strand 397,500-circ.mil steel reinforced conductor on the Balch-Sanger 110-kv. line. This line had been in service at that time approximately three years. This failure occurred where the conductor was clamped in the dead end fitting. From 12 to 18 strands were found parted at 18 different dead ends. The breakage was all in the aluminum, the steel core remaining intact. The span lengths where trouble occurred were from 1,900 ft. to 4,000 ft. long and were across canyons with prevailing winds at right angles with the line. The conductor was strung at approximately 2,500 lb. In November, 1927, the weakened conductor in these dead end clamps was repaired and Stockbridge 15-lb. dampers installed. These dampers were located six feet out on the conductor from the clamp. These dampers have effectively stopped the vibration in these spans.

During January, 1928, an inspection of 266,800-circ.mil all aluminum lines where the wind was at right angles to the line was made. This is a seven-strand conductor and while vibration was noted, the frequency was higher and no damage to the strands was noted. This line had been in service approximately seven years.

In June, 1928, a failure occurred on a 19-strand 397,500-circ.mil all aluminum line. This break took place at a dead end clamp. The line had been in service two and one-half years when this failure was noted. The line was exposed to almost continuous winds of from four to fifteen miles per hour. Vibration was almost continuous and very pronounced. Various vibration dampers were installed on this line, but none were wholly effective. It is estimated that the best result obtained was to reduce the vibration about 85 per cent. Therefore, it was decided that other precautions were necessary and the conductor was reinforced at the clamps with ½-in. stranded steel messenger. The messenger was extended through the clamp and attached to the conductor with cable clamps. See Fig. 5. These cable reinforcements have successfully acted as vibration dampers, reducing the vibration some 25 per cent.

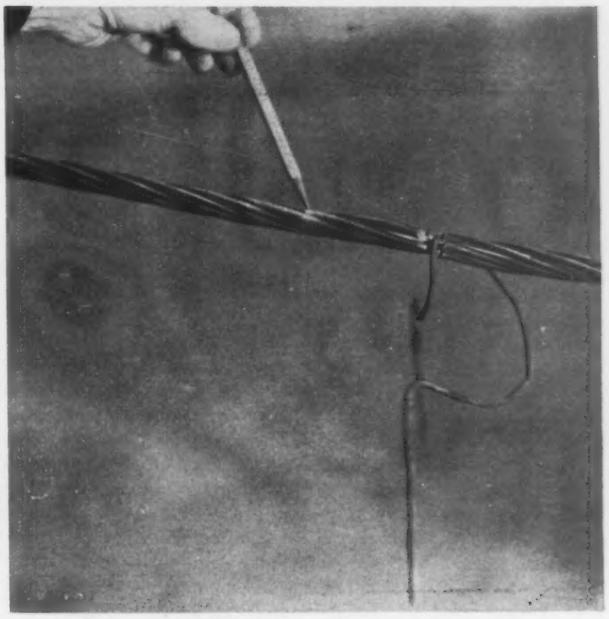

Fig. 7. Effect of vibration caused by loop of wire on 266,800 circ. mil all-aluminum conductor.

In October, 1928, excessive vibration was noted on 1/0 A.C.S.R. conductor used on distribution lines on our coast division. This conductor was tied on pin type insulators and the line was exposed to winds at right angles to the line. Several failures occurred on this line and an attempt was made to control the vibration by the use of weight dampers of several sizes and varieties. They did not prove effective, however, and the line was reinforced at the insulators with a length of the aluminum strand clamped to the conductor. This method has prolonged the life of the conductor but has not stopped the vibration.

During November, 1928, an inspection of vibration was made of a line constructed with 334,600-circ.mil A.C.S.R. This conductor was vibrating very severely. It had been in service about four years but no failures of strands were noted. In December, 1928, Stockbridge 10-lb. dampers were installed on three spans of this line. These dampers were placed 3 ft. 6 in. from the suspension clamp. See Fig. 6. They have proven very effective, completely damping the vibration. It is interesting to note that these same dampers were not effective on the 397,500-circ.mil all aluminum conductor mentioned above.

Thus the conclusion might be drawn as a result of the three years experimental work carried on, that while vibration can be controlled by the weight dampers on a fairly rigid conductor such as the A.C.S.R., it is very difficult to do so on a more flexible conductor such as the all aluminum. Trouble has also been experienced with No. 2 hard drawn solid copper on a 70-kv. line. Breakage occurred in one instance at a suspension clamp and in two cases at dead end clamps. The span lengths were short, approximately 250 ft., and the conductor was pulled to a very high tension. The vibration noted was of very high frequency. The line had been in service only a few months. Where vibration is severe, damage has also resulted to the supports as well as the conductor. Tower braces have broken, nuts loosened, etc. and the towers are sometimes extremely noisy.

Fig. 7 is an interesting example of the result of vibrations in a conductor. The strand photographed was 266,800-circ.mil all aluminum. A loop of No. 2 copper had in some manner been placed over this conductor. The continued hammering due to vibrations of the conductor had cut through 3 of the 7 strands. The pencil points to a place where the wire loop started its destruction but later it moved to a point further along the conductor.

The results obtained from the experimental use of the 10-lb. Stockbridge dampers on the 334,600-circ.mil A.C.S.R. line referred to above having proven very satisfactory, this line was completely equipped with these dampers in January, 1930. Since that time the line has been carefully inspected five times and no vibration has been noted. During the installation of these dampers the conductor was thoroughly looked over and no strand breakage had occurred.

During a heavy snow storm on January 12, 1930, a failure took place on the Exchequer-LeGrand 110-kv. line. This line is constructed of 266,800-circ.mil 7-strand all aluminum conductor and is supported on wood poles spaced 350 ft. The conductor was pulled to approximately 1,000 lb. The break occurred at a suspension clamp and upon examination it was found that the nuts on the J-bolts had loosened due to vibration, allowing the conductor to rub against the clamp and keeper so that a portion of the strands had parted. The snow load proved too great for the weakened conductor. This line was constructed some seven years ago and at that time no lock washers were used on these J-bolts. The balance of this line was inspected and three other clamps were found that had loosened in the same manner and where the conductor was badly worn. Where the conductor was rigidly held in the clamp, no damage was found to the strands.

On the 70-kv. line from Merced Substation to Poso Junction, which was constructed in 1927, a failure also occurred during this snow storm. The cause was found to be a weakened conductor from broken strands due to vibration. The line is 266,800-circ.mil 7-strand all aluminum supported on wood poles with 350-ft. spans. An inspection of this entire line, which is 23 miles long, was made and damaged conductor was found along a stretch four miles long. The tension was checked and found to be from 970 lb. to 1,050 lb. From one to three strands of the conductor were found broken at 43 poles out of the 65 in this distance.

Tension was checked and the conductor examined on the balance of this line but no further strand failure existed. The tension was found to be from 800 to 900 lb. The whole line is exposed to prevailing winds at right angles to the line and the only reasonable explanation for the fact that the damage is restricted to the 4-mile stretch seems to be the slight difference in tension noted.

Reinforcement was decided upon as the best procedure in this case and a method similar to that shown in Fig. 5 was used. It differed, however, in that two lengths of ⅜-in. 7-strand steel messenger 6 ft. 6 in. long were used in conjunction with a 4-ft. 4-in. length of ¼-in. messenger. The ⅜-in. strand entends 4 ft. 4 in. from the clamp center and the ¼-in. piece extends 2 ft. 2 in. Thus the ⅜-in. strand is double for 2 ft. 2 in. each side of the clamp center, this double part being the same length as the ¼-in. strand. All is fastened to the conductor by means of four ⅝-in. cable clamps. This assembly is shown in Fig. 11.

Notes on Conductor Vibration From One of the Wire Manufacturers

The summary of conductor vibration can be divided into three parts—

1. The nature and cause of vibration in overhead conductors.
2. The effects of vibration on conductors.
3. Methods and means of avoiding or overcoming injurious effects of vibration to the conductor.

It is now known that there is a definite tendency for some types of conductors when strung on overhead construction to vibrate under certain wind conditions. This tendency to vibrate and also the amount of vibration is affected by a number of different factors, such as size of conductor, its weight and tension, as well as by wind or climatic conditions.

Effect of Size—

For a given conductor material, smaller sizes tend to vibrate more than large sizes. For example, nearly everyone has noticed the vibration of small copper telephone and telegraph wires, such as No. 10, No. 9 and No. 8 A.W.G on wood pole construction. Slightly larger sizes, such as No. 6 and No. 3 A.W.G. which are used on many lines of the power companies, are found to vibrate only at certain times and apparently only under certain peculiar conditions, while large copper conductors seldom, if ever, vibrate.

Effect of Specific Weight of Conductor Material

Conductors of light weight material appear to vibrate more readily and more frequently than those of heavier weight materials. An example of noticeable vibration which was brought to our attention was on a line where a light weight large diameter weatherproof wire was used. The conductor size was about No. 4 and the insulation was approximately ½ in. thick with a result that the weight was small compared to the diameter. There is apparently a relationship between the tendency to vibrate and the ratio of the weight of the conductor to its diameter. The smaller this ratio, the greater the tendency to vibrate.

Conductor Shape—

The shape of the conductor also has some bearing on the tendency to vibrate. For example, on one line which was being inspected regularly, No. 4 solid wire was found to vibrate quite frequently whereas a 3-wire strand of the same material, and approximately the same size, similarly installed, did not vibrate at any time when inspected. The ratio of the weight to the diameter was slightly less in the 3-wire strand than in the solid wire, but apparently the shape of the strand broke up any tendency for the wind to start the conductor vibrating, or for it to maintain or build up vibrations to any extent.

Effects of Vibration on Conductors—

When a conductor vibrates, the wire is subjected to a bending in conforming to a wave shape. This bending of a wire causes a bending stress in the wire, which stress is in addition to the stress due to normal tension. On the convex side of the bend, the stress is added and on the concave side the stress is reduced. The amount of this additional stressing depends on the amount of bending and on the wire diameter, or, rather, the radius of the wire. In most instances the vibration of the conductor causes no injury to the wire and it is only where the bending becomes excessive that failures may be expected.

In the usual types of construction wire failures due to vibration seldom occur, although, if wire is strung with a tension very near its elastic limit, or, rather, its endurance limit, the additional stresses caused by vibration would be expected to cause failures in the span. Usually breaks which do occur are at the points of attachment, that is, at the clamps, either at suspension supports or at dead-end supports. At these points, the wires are subjected to appreciably more bending than at other portions of the span. The greater weight of the clamp causes it to have a high moment of inertia and movements of the wire result in the wire being rather sharply bent at the lip of the clamp, the effect being practically the same as where wire is held in a vise and bent back and forth until failure occurs.

One other type of line trouble caused by vibration should be considered, that is, where the wires are improperly attached to pin-type insulators, either by being loose on the insulator or in having considerable play between the wire and the tie wires. For example, if the wire is attached to the insulator with a hard-drawn tie wire, the latter has a certain amount of spring and cannot be applied so that it has a close fit on the line wire. An inspection will show that the tie wire springs back somewhat like a coil spring and that clearance exists between the tie wire and the line wire. With this condition and vibration, the line wire keeps striking and rubbing against the tie wire until nicks occur and failures follow. These failures are due to chafing and wearing and are not due to excessive bending such as previously mentioned. The trouble is sometimes known as "tie wire burns."

Method and Means of Avoiding or Overcoming Injurious Effects of Vibration to the Conductor—

Using conductors which experience shows are practically free from vibration is one method of avoiding all vibration difficulty. As previously mentioned, inspection of lines indicates that conductors which have high ratio of weight to the diameter are relatively free from vibration. Most of the large size power conductors on transmission lines and on long spans apparently meet this condition. There may not be any critical value of weight to diameter, which would distinguish between lines that would and would not vibrate, and the effect may be only relative, however, it appears that the higher this ratio, the less tendency there is for vibration. It should also be noted that for a given material this ratio increases as the size of the conductor is increased.

Another means of guarding against failures due to vibration is by having normal tensions in the conductors sufficiently low that when the bending stresses caused by vibration are added to the normal tension, the total stress does not exceed the endurance limit of the material. The fact that most of the lines in the heavy loading districts have relatively low stringing tensions (factors of safety of about 4 or higher) may be one of the reasons why most of these lines have functioned for years without any indication of vibration trouble. On construction in districts where vibration troubles are known to exist another safeguard is to use stranded conductors rather than solid wires. The maximum fiber stress caused by bending is dependent on the wire diameter, increasing directly as the wire diameter. In a strand, due to the slippage between wires, the maximum fiber stress is less than that in a solid wire of the same diameter, although not reduced to the extent that the maximum fiber stress is proportionate to the individual wire diameter. The reduction, however, is sufficiently marked that the strand would withstand appreciably more bending than solid wire of the same diameter. It should not be assumed from this, however, that solid wire is not applicable for overhead construction, as experience has shown that, where properly installed, solid wires will give excellent service and are not subject to failures due to vibration.

Fittings and Attachments to Wires—

It is desirable to avoid all rigid attachments to the conductor, particularly on the smaller sizes of wires which are known to vibrate. Good flexibility may be had by proper design of clamps, both for dead-ending and for suspension supports. It is also important that the weight of fittings be consistent with that of the wire. Heavy fittings, even though having flexible attachments, nevertheless have high moments of inertia compared to the wire and will not swing with the conductor but will act practically the same as a rigid support. Instances are known where clamps suitable for ⅜- to ½-in. strand have been used for supporting solid wires where special keepers or pieces of wire as fillers were required in order to grip the line wire. This type of construction can easily be the cause of failure. Various methods of damping vibration on overhead lines have been experimented with and reports have been made that effective results have been obtained in some instances. A large number of methods have been suggested, but probably many of these have not been tested as yet. Experiments in damping vibration are rather elusive, as under certain conditions very marked improvements can be shown by using a particular method of damping, but with slight changes of other conditions vibrations are again in evidence with possibly as great an amplitude as under the previous conditions.

One method now being used for overcoming breakage in wires is by adding reinforcing wires to the conductor where clamps and fittings are attached. The amount of reinforcing may be relatively large at the fitting and tapered off several feet on both sides of the fitting. This reinforcement has the effect of gradually increasing the stiffness, weight and inertia of a wire as it approaches the clamp, and also in obtaining more consistency in the weight between the fitting and the wire. It also reinforces the wires at the point where subjected to the greatest bending forces. It has been reported that some excellent results have been obtained by this means.

Armor Rods to Reinforce Conductors Subject to Vibration—

Fatigue of conductor strands is assumed to result from rapid alternation of the stresses concentrated on a very short section of cable at or near a theoretical point of reflection of the waves. Armor rods distribute the stresses over a longer length by virtue of the fact that they increase the resisting moment of the cable. They also have a damping effect on the

amplitude of vibration by virtue of the less perfect reflection point, or possibly, better stated, by the distributed reflection.

Demonstration tests have been made on a large scale on spans 120 ft. long, in which very vigorous resonant vibration is forcibly maintained by means of a motor and spring connection. In these demonstration tests, the static tension in the cables has been taken at 70 per cent of the ultimate tensile strengtth. This tension is maintained for a period of about 30 hours until all measuring stretching has ceased before the vibration is started. This base tension is then maintained throughout the test. Under these conditions the unit stress in the aluminum strands is of the order of from 17,000 to 18,000 lb. per sq.in. This stress in the aluminum is very much higher than would exist in any transmission line under conditions accompanying resonant vibration. This high stress value, however, is used to insure fatigue failure under vibration in the laboratory within a reasonable length of time. The use of armor rods has clearly demonstrated in a large number of tests a life under high stress conditions more than 50 times as great as without the rods; that is, 50 times as many cycles to failure of conductor strands. Actually one test has shown as high as 200 times.

From these statements it cannot be directly argued that the life of an actual transmission line conductor is multiplied by 50 by the use of rods. The argument is rather that a reduction in stress is obtained by the use of the rods. Since there are many more lines which have not broken from fatigue than the number of those which have broken, it is presumable that stresses commonly existing on actual lines are more or less near the border line between safety and danger from vibration fatigue. It is therefore reasonably presumable that the reduction in stress resulting from the use of rods under high stress conditions will give adequate results under the lower stress conditions existing on actual lines. In this connection it should be remembered that resonant vibration is an "unloaded conductor" phenomenon and that the highest values of stress in the aluminum are probably on the order of 9,000 lb. per sq.in., and more frequently less than that. Actual field service has been observed on one line for a period of five years at certain points where fatigue breakage had occurred previously in a period of two years. Results have been entirely satisfactory to date, even though the rods are considerably less adequate than the present design.

Armor rods protect the conductor against burning from insulator flash-overs and have a reinforcing effect on the tensile strength of a conductor. In this respect the rods act in a way similar to what a lineman calls a grapevine grip. Several tests have been made to show this tensile reinforcement. A 50-ft. length of 397,500-circ.mil A.C.S.R. (30/7) was placed in a testing machine. At a point near the center all the aluminum strands were cut over a space of 5 in. along the cable. Tapered rods were installed in the usual way and a suspension clamp applied in the usual way. The suspension clamp was centered over the severed strands. At a load of 19,160 lb. the cable failed by fracture of the steel core inside of the suspension clamp where aluminum strands were cut. The first slippage of any kind was noted at a load of 17,000 lb. This was a slippage of 1/16 in. It was noted at one end of the rod assembly.

An exactly similar test was run, except that no suspension clamp was applied over the rods; i.e., the reinforcing effect

Fig. 9. Armor rod reinforcement applied to 750,000 circ.mil A.C. S.R. Rods 10 ft. long.

of the suspension clamp was omitted. Failure occurred by fracture of the steel core at the point where the aluminum strands were cut, and at a load of 18,600 lb. The first noticeable slippage was 1/16 in. at one end of the armor rod assembly and at a load of 14,000 lb. The nominal ultimate strength of 397,500-circ.mil A.C.S.R. (30 aluminum, 7 steel strands) is 19,170 lb.

Pacific Gas and Electric Company Experience

The Pacific Gas and Electric Company reports having experienced serious trouble on only one line. The conductor is 266,800-circ.mil, 19-strand aluminum strung at a very low tension. Strand breakage occurred at the suspension clamps. The conductor was reinforced by means of a jumper of the same material clamped and served to the conductor. The jumper was placed in the suspension clamp. The detail of this repair is shown in Fig. 10.

Conductor Movement Due to Short Circuit Stresses

This subject was covered in a report on conductor movement published in the 1928-1929 Proceedings of the P.C.E.A., and in a paper by William S. Peterson and H. J. McCracken, Jr., of the Bureau of Power and Light of Los Angeles, presented at the Pacific Coast convention of the A.I.E.E. at Spokane, August 28-31, 1928.

The conclusions of the authors of this paper were as follows:

1. It is necessary to take account of short circuit forces in designing overhead lines.
2. Present mathematical and experimental data on the movements of overhead conductors during short circuits are very incomplete. A large field exists for research on this problem.
3. It would seem that the improvements in system and line design that can come from a study of this problem would justify various central station companies in extending and making public the research on this subject.

One operating company which uses a 4-pin, 8-ft. arm for its 3-wire, 11-kv. lines with 25-in. pin spacing between nearest

Fig. 8. Armor rod reinforcement applied to 266,800 circ.mil all-aluminum conductor. Rods 48 in. long.

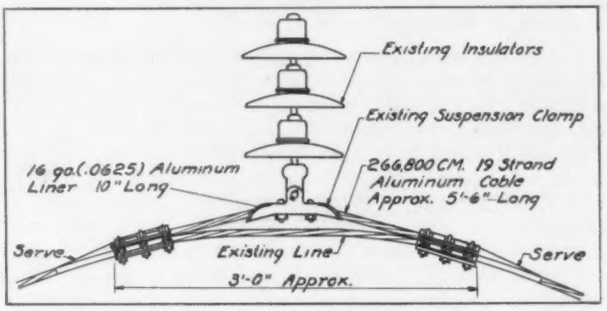

Fig. 10. Method of reinforcing conductors at suspensions on 100-kv. transmission lines.

wires has experienced some difficulty with these wires swinging together during short circuits. This occurred on spans less than 250 ft. long. As a result they have adopted a staggered center wire construction which gives an average 42-in. spacing. This increased spacing has resulted in eliminating the trouble.

This same company has also had considerable difficulty with breakage of locust pins due to short circuit stresses. They are now using a steel pin on all main distribution lines.

As system and substation capacities increase, the possible short circuit current values and resultant mechanical stresses also increase materially. Considerable data is available regarding such stresses in buses and their supports but very little has been made public with respect to movement of conductors and the resultant stresses in their supports for overhead lines. The conclusions of Messrs. Peterson and McCracken, quoted above, to the effect that further study and research on this subject is justified, are well taken.

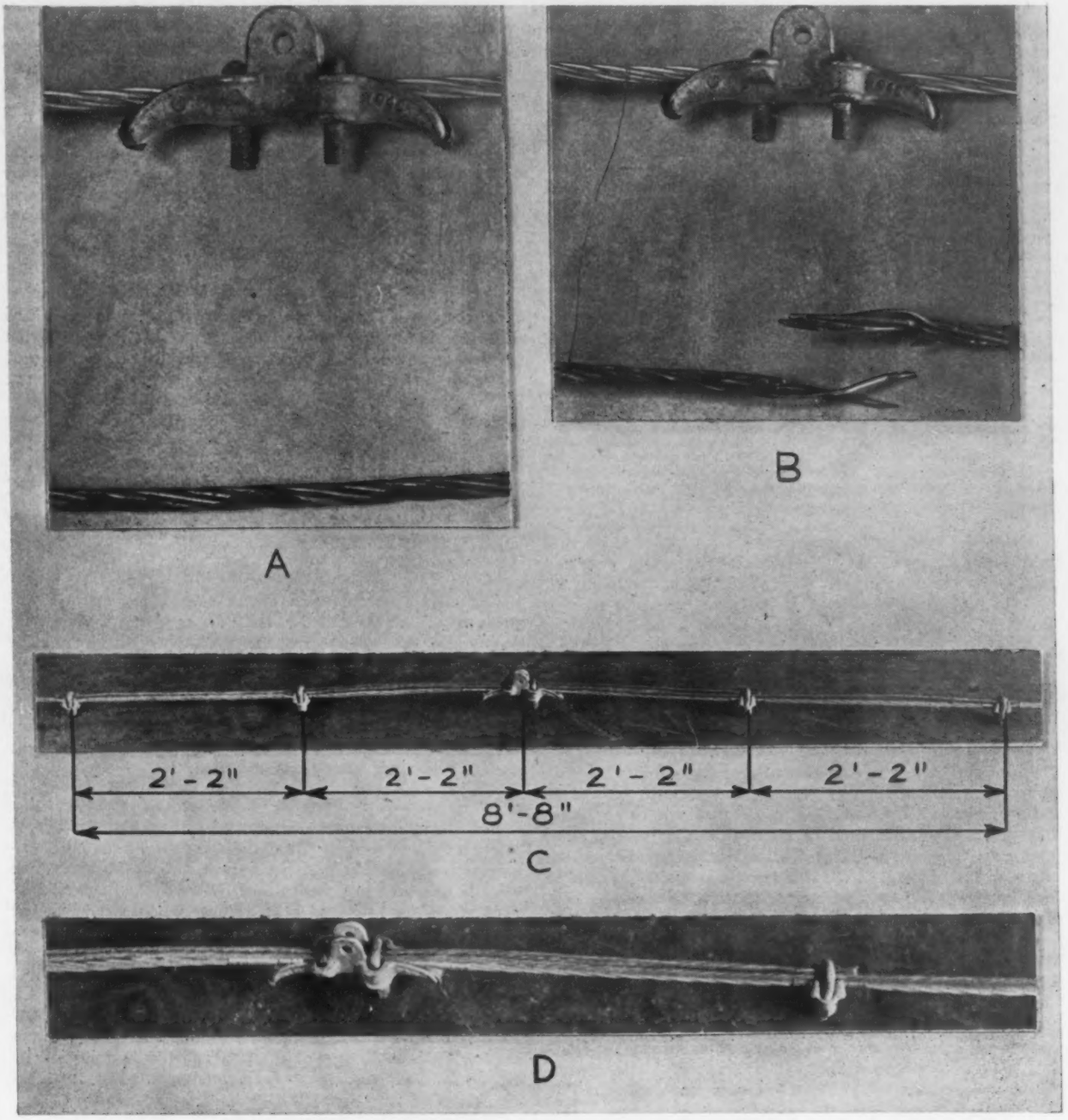

Fig. 11. Damage to 266,800 circ.mil all-aluminum conductor. Method of reinforcement. A. Clamp as found with j-bolt nuts missing. Strands of conductor partly worn. B. Conductor which parted after being damaged by vibration. C. Reinforcement applied to this line. D. Detail of reinforcement.

Conductor Movement Due to Ice or Sleet Unloading—"Dancing Conductors"

Reports of "dancing conductors" have been quite prevalent during the last few years from other parts of the country and have resulted in considerable discussion in the press. Very little such trouble has been experienced by the Pacific Coast companies, however, but some outages have been caused from snow or ice unloading from a lower conductor, causing it to whip up into a loaded conductor over it. This has occurred principally on lines using vertical construction and on long spans. One method used to obviate this trouble is to place the middle conductor so that it is not in the same plane as the other two.

The following comment from the California Oregon Power Company regarding the use of armor rods, which involves also an instance of "jumping conductors" is quite interesting.

> Armor rods have been giving satisfactory protection, so far as I know. We are installing them uniformly wherever we use steel core aluminum. We are using aluminum only on rural lines and in sizes 2 and 4, mostly No. 4, and on spans averaging 400 ft. and up to 500 ft.
>
> We have had no further trouble from loss of insulators on 110-kv. lines due to whip loads from dropping snow loads. We had only one case of this trouble on a line built in 1924.
>
> We recently had a peculiar case of "jumping conductor." Our line No. 12 was built in 1922 and described in the Jan. 20, 1923, issue of the *Electrical World*. We have just increased the voltage on this line from 66 to 115 kv., adding three insulators to the original string of four. It is now reported to us by our patrolmen and operators that whenever it rains the wires jump. They say that all three wires move vertically as much as 3 or 4 ft. This does not occur at any other time and does not take place when there is wind. The rain alone seems to do the trick in a dead calm. The conductor is No. 2/0, 7-strand, medium hard drawn copper, and the insulators are ball and socket. Wire was supposed to have been strung to the N.E.S.C. heavy loading, which gave a stringing tension at 60 deg. on a 500-ft. span of 910 lb. I believe the actual stringing tension was more nearly 10 or 12 per cent higher than this. The spans average 500 to 600 ft. in those districts where the jumping has been noted. The entire line does not jump, but several miles at the power house end and other sections farther up have been so observed.

From the foregoing experiences it is quite evident that under certain conditions vibrations are set up in overhead conductors that may greatly shorten the life of the conductor and its supports and may cause costly outages and repairs. While much excellent work has been done toward providing methods to obviate or minimize this trouble and these methods have proved quite satisfactory in many instances, there are some cases that they have not materially helped. Experimental work is being continued in an effort to find an answer for all cases.

The problem is one that merits thought and investigation. Because the danger to the conductor may be hidden by its supporting clamps it may be overlooked until a serious failure results. Then the real cause may not be corrected but the trouble attributed to other faults. Existing lines that may be considered free from vibration trouble may be more or less damaged. If vibration is suspected it will be well worth while to investigate the condition of the conductors.

Further study of movement of conductors due to short circuits and the stresses resulting therefrom is needed so that lines may be properly spaced and their supports given sufficient strength.

In the snow and sleet regions line design should be such as to guard against the sudden unloading of one conductor, causing it to whip into one above it, and where "dancing conductors" occur, the design should be such as to care for this movement.

It is the hope of this subcommittee in presenting this report that the experiences and comments herein may prove of value to those charged with the duty of constructing and operating overhead lines.

*Corrosion of Metals**

This report deals particularly with the corrosion of transformer cases, hangers, pole top switches and line hardware.

AFTER due consideration of all the reports submitted by member companies, the committee feels that the best solution to date of corrosive troubles lies in the use of a good grade of galvanizing.

Transformer Cases

The corrosion of sheet steel transformer cases, particularly in areas adjacent to salt water, has caused some trouble.

The Southern California Edison Company has adopted aluminum paint with a varnish vehicle base as protection. This was done due to the fact that the aluminum is more resistant to moist atmosphere and direct rays of the sun than any comparable protective coating. The aluminum is applied with a spray gun for the reason that a better coating is obtained than if applied by brush. It is expected that the aluminum will resist corrosion for a period of ten years.

While all companies agree that galvanizing has merit, they are not quite ready universally to specify galvanized transformer cases. The Pacific Gas and Electric Company reports the use of galvanized radiators on power transformers. This is working out very well.

Transformer Hangers

The corrosion of black metal transformer hangers has caused some serious troubles for a few of the companies and they have now adopted galvanized hangers. In one case of corrosion reported, the hangers of a 7½-kw. transformer failed due entirely to corrosive action permitting the transformer to drop, causing severe damage.

Pole Top Switches

Several companies report considerable trouble due to corrosion of clamping bolts and hardware. These bolts and pieces of hardware had been galvanized but the work was apparently of an inferior nature.

Line Hardware

Considerable trouble has been caused by corrosion of pressed steel clevises. All of the clevises giving trouble were galvanized but apparently the work was of an inferior nature.

A number of specimens of stainless steel clevises have been installed and the results noted from time to time. The observations indicate that stainless steel is not immune from corrosion. Several reports indicate that specimens have corroded within a three-months' period.

Corrosion in General

Reports indicate that corrosion is still causing trouble to tower steel. Paint has been used primarily as an anti-corrosive application and the indication is that unless the steel is properly prepared either by sand blasting or chipping, the paint is but of little value. Where sand blasting has been resorted to, the results have been good. One company is considering a new process for use on steel towers known as a metal spray. This consists of coating iron and steel with zinc or any other material which may be desired.

For earth footings located in alkaline soils one company has found it advisable, in addition to galvanizing, to apply a coating of asphalt emulsion. This is done in the field by dipping and the coating is approximately 1/20-in. in thick-

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* Report of subcommittee on corrosion of metals, overhead systems committee, Engineering Section. N. P. Carlsen, chairman. C. A. Andrews, F. E. Blausey, C. B. Carlson, M. N. Clark, A. S. Glasgow, W. W. Glosser, C. B. Judson, G. E. Nott, H. M. Teppersen, C. C. Wilson.

ness. Asphaltic emulsion seems to be one of the few effective coatings which will adhere to a galvanized surface.

Conclusion

The committee suggests the adoption by all companies of galvanized transformer hangers.

The committee recommends for pole top switches the use of bronze or similar alloy or a good grade of galvanized hardware.

For line hardware the committee suggests the use of so-called galvanized malleable iron wherever possible, or, if pressed steel is used, it should be thoroughly galvanized.

The committee recommends the adoption by all companies of standard specifications for galvanizing. Refer to specifications which are being considered by the American Standards Association.

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*Methods of Securing Satisfactory Grounds**

During the past year the subcommittee on the above subject has been continuing the study started a few years ago. This study included the various types of grounds such as water pipe, gas pipe, and driven grounds under various soil conditions and during the dry and wet seasons. The object of the study has been to determine the most satisfactory grounds consistent with as low a cost as possible.

THE question of the cost of grounds is unusually prominent due to the larger number of grounds now required, particularly on systems requiring multiple grounds. In addition to the original cost of grounds, the question of maintaining them and of testing them periodically is an equally important factor.

From the studies conducted so far the following conclusions appear to be outstanding:

1. The most satisfactory ground and the one which apparently shows the least variation throughout the seasons is the water or gas pipe ground. However, the use of water systems may be curtailed somewhat as indicated later.

2. Where conditions are such that driven grounds are the only ones available it is advisable to use two driven grounds in place of one as has been the practice in the past. By the use of two grounds driven at a distance of six feet or more apart, considerable decrease in resistance can be obtained at a comparatively slight increase in cost over the single and less satisfactory ground.

3. The availability of accurate, portable, self contained, resistance measuring instruments capable of measuring a wide range of values makes the problem of obtaining initial and periodic tests of grounds much simpler and less expensive than heretofore. The elimination of the necessity of using the three-point method for ground testing, requiring considerable equipment and time, and using in its place the modern resistance measuring devices, is one of the outstanding features in securing and maintaining satisfactory grounds.

In regard to the use of water systems for grounding, the present attitude of the American Water Works Association will do doubt have some bearing on this practice. During 1929 at a convention of the American Water Works Association, its 1920 indorsement of the grounding of secondaries of lighting transformers was modified as follows:

1. The A.W.W.A. approves the practice of grounding the secondaries of lighting transformers on water pipes for the purpose of safeguarding life and property, provided that appreciable electric current flows over such ground connections only during comparatively short and infrequent intervals when the ground connections are fulfilling their specific protective purposes, and provided that such ground connections impose no responsibilities on the pipe owning company.

2. The A.W.W.A. is opposed to the use of water pipes as electrical conductors, except as noted above, and since experience with certain power distribution practices which have come into use, has shown that grounding may result, and in many cases has resulted, in hazard to the pipe structures and water works employees, it hereby withdraws its former general endorsement of grounding on water pipes.

From this resolution it is apparent that in the future more dependence will have to be placed on driven grounds and probably certain restrictions will be placed on the use of water systems. The question of grounding to the gas system has been discussed in the committee meetings. Modern gas system piping is generally built up with welded joints between the sections of pipe, and as a result the gas system may be equally as good as the waetr system for a ground. However, the members present at the meetings expressed the opinion that it might be some time before all the operators of gas systems become convinced that no danger will result to their systems as the result of grounding to them.

The use of driven grounds for distribution systems has been given considerable study during the past five years, particularly from the standpoint of methods of installing and reliability of maintenance. The second phase of this subject has been a study of methods to reduce the cost to a minimum consistent with obtaining grounds having a reasonably low value of resistance. The third phase is the utiliza-

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* Report of subcommittee on grounding, overhead systems committee, Engineering Section. E. R. Stauffacher, chairman. P. Diederich, O. R. Evans, J. H. Fagg, A. R. Fryklund, A. S. Glasgow, G. A. MacDonald, E. A. McGinty, E. Y. Porter, M. C. Richardson, G. A. Riley, Ray Sheppard, D. D. Smalley, E. Walters.

TABLE I—Ground resistance test data—3-point method.

Location of Test Rod (All points in vicinity of Los Angeles)	Type of Soil	Resistance Values								
		Test Rod Resistance—Ohms			Auxiliary Grounds Resistance—Ohms					
		Apr. 1929	Sept. 1929	Jan. 1930	Apr. 1929	Sept. 1929	Jan. 1930	Apr. 1929	Sept. 1929	Jan. 1930
La Canada Pole number 203434-E	Coarse sandy loam	51	68	80	0.07 Water pipe	Neg.	Neg.	44 Guy wire	121	52
La Crescenta Pole number 29261-E	Sand and small boulders	367	1061	361	251 System ground rod	678	572	56 Water pipe	119	101
Flintridge Pole number 202593	Fine sandy loam	11	11	14	25 System ground rod	46	39	30 Guy wire	100	93
Alhambra Pole number 175736-E	Clay and loam	8	7	8	4 System ground rod	6	7	0.89 Ornamental street lighting ground bus	0.94	1.3
San Gabriel Pole number 92081-E	Red clay	89	151	161	74 System ground rod	103	93	11 Water meter	0.24	10
Rosemead Pole number 257913-E	Black adobe and sand	21	26	21	18 System ground rod	20	23	3.7 Water meter	3.3	3.2

TABLE II—Tests showing varying ground resistances encountered in Long Beach, Calif., area.

Pole No.	Resistance of Ground Under Test (Ohms)	Resistance of Auxiliary Ground (Ohms)	Resistance of Auxiliary Ground (Ohms)*
153500E.....	Water main R = 0.2	Overhead grid R = 0.1	Guy anchor (100 ft.) R = 6.2
194904E.....1	1 in. x 8 ft. pipe R = 13.8	Overhead grid R = 0.12	Water pipe (75 ft.) R = 0.13
213559E.....2	⅝ in. x 8 ft. copperweld rods R = 2.74	Overhead grid R = 0.12	Water pipe (15 ft.) R = 0.11
164009E.....1	1 in. x 8 ft. pipe R = 12.7	Overhead grid R = 0.51	Guy anchor (20 ft.) R = 23.0
399508E.....2	⅝ in. x 8 ft. copperweld rods R = 6.5	Overhead grid R = 0.12	Water pipe (30 ft.) R = 0.22
195274E.....1	1 in. x 8 ft. pipe R = 2.1	Overhead grid R = 0.1	Water pipe (80 ft.) R = 0.1
307693E.....1	1 in. x 8 ft. pipe R = 3.1	Overhead grid R = 0.07	Water pipe (50 ft.) R = 0.11
163957E.....2	⅝ in. x 8 ft. copperweld rods R = 4.4	Overhead grid R = 0.18	Water pipe (65 ft.) R = 0.17
263864.....1	1 in. x 8 ft. pipe R = 0.53	Overhead grid R = 0.18	Water pipe (90 ft.) R = 0.15
372718E.....1	1 in. x 8 ft. pipe R = 3.7	Overhead grid R = 0.1	Water pipe (35 ft.) R = 1.5
324462E.....2	⅝ in. x 8 ft. copperweld rods R = 1.76	Overhead grid R = 0.41	Guy anchor (18 ft.) R = 15.0
220564E.....2	⅝ in. x 8 ft. copperweld rods R = 32.0	Overhead grid R = 0.68	Guy anchor (30 ft.) R = 82.0
220544E.....1	1 in. x 8 ft. pipe R = 13.2	Overhead grid R = 0.15	Water pipe (45 ft.) R = 1.44
357195E.....1	1 in. x 8 ft. pipe R = 18.6	Overhead grid R = 0.57	Guy anchor (25 ft.) R = 61.0

*Distances noted are from pole to auxiliary ground.

TABLE III—Ground tests in the vicinity of Redondo, Calif.

Pole No.	Resistance of Ground Under Test (Ohms)	Resistance of Auxiliary Ground (Ohms)	Resistance of Auxiliary Ground (Ohms)*
No number...2	1 in. x 8 ft. pipes R = 3.5	Overhead grid R = 1.27	Rod driven in water R = 3.0 (45 ft.)
69660E.....2	1 in. x 8 ft. pipes R = 2.3	Overhead grid R = 0.8	Guy anchor (22 ft.) R = 7.5
314730E.....2	1 in. x 8 ft. pipes R = 2.2	Overhead grid R = 0.62	Guy anchor (45 ft.) R = 9.5
398375E.....2	1 in. x 8 ft. pipes R = 3.4	Overhead grid R = 0.67	Guy anchor (120 ft.) R = 16.1
350422E.....2	1 in. x 8 ft. pipes R = 1.82	Overhead grid R = 1.15	Metal fence in water (50 ft.) R = 0.57
32808E.....1	1 in. x 8 ft. pipe R = 14.7	Overhead grid R = 1.06	Isolated water System (45 ft.) R = 1.76
68730E.....2	1 in. x 8 ft. pipes R = 3.8	Overhead grid R = 0.61	Water pipe (85 ft.) R = 1.04
38614E.....	Water main R = 0.37	Overhead grid R = 0.80	Steel auger (40 ft.) (3 ft. in ground) R = 147.0
314719E.....2	1 in. x 8 ft. pipes R = 16.0	Overhead grid R = 1.3	Water pipe (75 ft.) R = 0.19
358824E.....2	1 in. x 8 ft. pipes R = 8.1	Overhead grid R = 1.6	Water pipe (45 ft.) R = 0.56
90955E.....	Water main R = 0.36	Overhead grid R = 1.0	Driven iron rod (40 ft.)—(5 ft. in ground) R = 53.0
No number...2	1 in. x 8 ft. pipes R = 9.9	Overhead grid R = 0.75	Guy anchor (65 ft.) R = 48.0
228979E.....2	1 in. x 8 ft. pipes R = 2.7	Overhead grid R = 0.79	Water pipe (65 ft.) R = 1.25
321157E.....	Water main R = 0.32	Overhead grid R = 0.64	Steel auger (22 ft.) (2.5 ft. in ground) R = 22.0

*Distances noted are from pole to auxiliary ground.

TABLE IV—Ground rod tests in Dundas (Ontario, Canada) rural power district.
Date, Feb. 23-27 — Temp., 36 degrees F. to 38 degrees F. — Weather, a.m. dull; p.m. clear — Snow, soft and wet, very sloppy.

Transformer Location	Micro-Amp.	Cal. Curve.	Amp.	Volts	Ohms	Previous Test Resistance	Auxiliary Used Ground	Remarks
37	72	b	8.4	266	31.7	17.2	Anchor	.....
42	62	b	7.9	184	23.4	22.1	Anchor	.....
36	61	b	7.85	160	20.4	13.6	Anchor	.....
35	68	b	8.2	232	28.3	14.1	Iron fence post	Frost 13 in. deep.
41	72	b	8.35	172	20.6	14.0	Anchor	.....
32	72	b	8.35	172	20.6	13.4	Anchor	.....
31	74	b	8.45	162	19.2	11.1	Iron gate post	.....
30	18	a	3.65	112	30.6	17.2	Anchor	Guy wire around both grounds.
29	82	b	8.8	70	7.9	5.5	Anchor	In barnyard drain.
28	73	b	8.4	235	28.0	14.4	Lightning rod-barn	Beside woods
27	66	b	8.1	348	43.0	30.8	Anchor	Beside woods
Mrs. Tunis	32	b	6.1	675	110.0	61.3	Anchor	.....
H. Vallesi	77	b	8.6	198	23.0	15.0	Service ground-house	Exposed to frost.
M. Ciaramicole	68	b	8.2	238	29.0	16.6	Lightning rod-barn	Exposed to frost.
R. Watson	62	b	7.9	330	41.8	13.3	Anchor	Exposed to frost
T. P. Connell	68	b	8.2	234	28.5	15.6	Anchor	Exposed to frost
H. Dyment	60	b	7.8	190	24.3	15.5	Anchor	Exposed to frost
A. W. Binkley	70	b	8.25	242	29.3	16.6	Service ground-house	Exposed to frost
C. H. Smith	70	b	8.25	212	25.7	14.0	Anchor	Exposed to frost

TABLE V—Ground rod tests in Dundas (Ontario, Canada) rural power district.

Date, Feb. 22-27. — Temp., 28 degrees F. to 32 degrees F. — Weather, a.m. clear; p.m. dull; 3:30 p.m. heavy snowfall. — 6 in. to 1 ft. of fresh snow, dry and light.

Transformer Location	Micro. Amp.	Cal. Curve	Amp.	Volts	Ohms	Previous Test Resistance	Auxiliary Ground Used	Remarks
69[1]	99	b	9.45	220	23.3	14.0	Gas tank	Frost 20 in. deep
70[2]	104	b	9.6	310	32.2	20.0	Iron fence post	Frost 16 in. deep
54	49	b	7.25	402	55.5	40.0	Gas tank	.....
53	54	b	7.5	380	50.8	32.0	Iron pump	.....
52	30	b	6.0 est	900	150.0	108.0	Tower high tension line On hill	.....
Harpers Corners	25	a	5.3 est	1,000	188.0	110.0	Tower high tension line	.....
51	32	b	6.3	650	103.2	54.0	Iron fence post	.....
66	72	b	8.35	162	19.4	14.2	Service ground at house	.....
65	92	a	6.55	570	87.4	30.0	Service ground at church	.....
56	84	a	6.35	750	118.0	66.0	Telephone ground at house	.....
57	52	b	7.4	345	46.7	45.5	Anchor	Salted Nov. 1926
58	50	b	7.3	590	81.0	37.2	Anchor	.....
59	47	b	7.15	500	70.0	74.7	Anchor	Salted Nov. 1926
60	115	a	6.95	530	76.5	43.0	Lightning rod-barn	.....
61	65	b	8.1	260	32.2	25.4	Anchor	.....
62	64	b	8.0	305	38.1	27.0	Anchor	.....
68	122	a	7.2	222	31.0	18.1	Anchor	.....
67	72	b	8.3	252	30.5	16.6	Iron pump	.....

62 per cent increase due to frost averaging 18 in. penetration.

[1]—Pole at location 69 was on level ground.
[2]—Pole at location 70 was on side of ditch and frost depth was taken at right angles to surface.

tion of known methods of testing to determine the value of the grounds and the use of self-contained testing instruments. The present tendency as well as the standard practice of at least one company is to drive two ground rods at a minimum distance of six feet apart and to connect both ground rods to the ground wire which leads down the pole. This connection between the rods and the junction is made by rugged connectors and No. 2/0 bare cable. The size of the wire leading down the pole is no smaller than No. 4.

In the past the generally accepted method of testing to determine the resistance of a ground has been by the so-called "three-point method." During the past year comparisons have been made between this method and the use of self contained portable testing instruments of the "megger" and "ground ohmer" types. As the result of these experiments as well as from considerable field experience, it has been found that these instruments check each other very closely and also check the values taken by the three-point method. The ease and speed with which the resistance values can be obtained with the portable instruments makes their use quite desirable from the standpoint of speed and cost of doing the work. As a result of this there is no doubt but that in the future more distribution grounds will be tested both at the time of initial installation and at more frequent intervals than is possible with the three-point method.

The tests which have been made during the past year show that the resistance values of multiple grounds incorporated in the "overhead ground grid" is quite low and well within the tentative values considered as a safe value of resistance.

Attached to this report are a number of tables giving the resistance values of a number of ground rods and water pipes together with the auxiliary ground used in making the test. All of the tests were made in the Pacific Coast territory except the tests submitted from Canada, which arrived too late to be included in the last year's report on grounding.

Ground Tests—Hydro-Electric Power Commission of Ontario

Resistance Tests on Driven Grounds—During November, 1926, tests were made on 37 isolated ground rods used at transformer locations in the Dundas rural power district. The values obtained were believed to be low since the tests were made just after a very wet season. It was proposed by the committee on driven grounds that further tests should be made on these same rods to show the change in resistance with the change in seasons. To show the effect of frost on the resistance, the rods were tested a second time in February, 1927, wher there was an average penetration of 18 inches. The results of this test are shown in Table IV.

Comparing Average Results

Average resistance of 37 grounds, Nov., 1926—30.2 Ohms.
Average resistance of 37 grounds, Feb., 1927—49.1 Ohms
Increase in resistance 62 per cent.

Two of the rods (locations No. 57 and No. 59) included in these tests had been treated with salt. The variation in resistance before and after salting and under frost conditions is of interest.

Resistance Tests—Driven Grounds

	No. 57	No. 59
Resistance in ohms, Nov. 4, 1926	66	150
Salt treatment carried out on Nov. 6, 1926.		
Resistance in ohms, Nov. 10, 1926	45.5	74.7
Resistance in ohms, Feb. 22, 1927	46.7	70.0

*Essential Features of a Multi-Party Joint Pole Contract**

A joint pole contract must be administered and operated on a non-profiting basis for the utilities involved. Its obligations and responsibilities are mutual. The closest scrutiny should be given to the economic values involved. These notes are intended to specify the fundamentals of such a contract and to enumerate certain principles in equity. This shows the contract in perspective. The data are available for a complete economic study of joint use and it is hoped that a future committee will undertake this task.

Part I—Form of Contract

Section 1. Preliminary—

THE legal preamble to the contract may include the names of all utilities or subscribers thereto. However, as the contract is effective and enforceable only as applied to subsequent specific agreements, supplementary to the contract, a statement of the original subscribers, general in character, is usually held sufficient, referring also to such other utilities as may hereafter subscribe to the contract. Specify the limitations affecting the life of the contract.

Section 2. Scope—

The contract should include principles and practices only as far as practicable. There should be no abridgement of existing rights or of those which may hereafter be obtained. The right to abrogate if practicable or maintain if desirable preexisting obligations should be clearly established. The right to buy, sell or lease plant in whole or in part should be included. State the method whereby other utilities may enter into and fully participate in joint construction under the contract. Also, the method whereby any utility may withdraw from the contract and give status of existing joint poles in case of such withdrawal, and procedure for operation and replacement of such plant thereafter. The contract should not imply, by inference or otherwise, that any franchise or rights are conveyed by joint use. Each utility must operate under permits or franchises granted by legally constituted authority. Define the general area where contract is operative, and give other limitations necessary or desirable within the scope of such a contract.

Briefly, the intent of the contract should be to use the least number of poles practicable for all purposes of the subscribers thereto, each utility retaining for itself the right to determine all matters affecting it, pertaining to entering into joint use, continuing in or abandoning joint use. The primary purpose of the contract is to promote the joint use of poles and facilitate the initiation and completion of specific transactions in accordance with the principles and practices of the contract and specifications which are a part of the contract.

Section 3. Organization—

In organizing to administer the contract, complete independence of the utilities should be maintained. This implies equal representation and authority for each utility, regardless of its magnitude or affiliations. An association or committee of the utilities meets the requirements of such an organization. This should be an unincorporated non-profiting unit of co-operation with one representative selected by each utility. This requires the usual necessary officers and will involve certain by-laws covering general and specific re-

* Report of subcommittee on joint pole practice and construction rules, overhead systems committee, Engineering Section. J. E. Macdonald, chairman. C. A. Bennett, H. L. Caldwell, D. I. Cone, R. E. Hill, C. T. Mess, A. C. Putnam, L. B. Smith, R. M. Spencer, C. E. Young.

quirements, such as meetings, proper notices, manner of securing decisions, rights of absent representatives, proxies and such other matters as may seem to be desirable.

Section 4. Administration—

Administration is effected through the central organization, committee or association with a secretary-treasurer as the administering executive, subject to the full direction of the representatives of the utilities in the central organization. Define the secretary's duties and responsibilities, the manner of his selection and replacement, the manner of fixing his compensation and expenses.

State regulations governing notices of meetings, order of business, and quorum. In general, no business should be taken up at one meeting and passed upon at that meeting, without proper notice having been given to all utilities at interest, unless, with full representation, the question may be decided upon unanimously. The administration should include the responsibility for preparation of plans and specifications for construction and reconstruction, initiation and completion of the records. The actual construction and operation of lines or the erection of poles for any of the overhead lines, are not functions of the central organization.

Section 5. Operation—

Decentralized operation and responsibility by utilities at interest with co-ordinated control by central organization is desirable. This may be effectively accomplished through local groups or committees. The secretary-treasurer usually acts in similar capacity for local groups.

Special agreements supplementary to the general contract are necessary for each specific transaction. These are local in character and should take the form of an authorization in writing for the approval of utilities at interest. Authorization may include all manner of joint pole work of whatever nature, provided it is in accordance with the principles and practices of the contract. All authorizations and other agreements affecting joint use, may be negotiated directly between the utilities at interest, but must be cleared through the central organization for permanent record.

Section 6. Limitations of Joint Use—

Joint use by two supply utilities with circuits at the higher transmission voltages, is not recommended as a general practice, nor by supply and communication utilities where supply utility's requirements include or propose to include, certain voltages detrimental to effective operation of the communication plant, or where the communication utility's requirements include toll or long distance lines. These problems as they arise should be considered on their merits and their analysis based on the best engineering solution. In general, it will be found that joint use is preferable to conflicting lines in co-linear construction.

Section 7. Liability—

It is frequently the practice to include a liability clause in joint pole contracts. The contention has been made at times that this is unnecessary for the reason that damages incident to joint use of poles are readily adjusted as between the utilities affected under the general principles of the contract. In other cases involving joint poles, adjustments must be made from a legal standpoint only and a liability clause has little bearing on the status of the damages incident to joint use. However, the intent of such a clause should be to hold the utility or utilities responsible for damages liable, in accordance with the facts which must be established.

Section 8. Arbitration—

In case of disputes arising out of the joint use of poles, the matter in dispute should be referred to the managements of the utilities at interest for settlement. In the event that said utilities cannot agree the matter may be referred for decision to a board of arbitration, consisting of persons who should be disinterested as between the parties to such dispute.

Section 9. Amendments—

Amendments to the contract may be initiated by any utility which is a party to the contract by submitting proposed amendment in writing to all parties to the agreement. This should be referred to the managements of the utilities for execution, and when signed by all utilities should become immediately effective.

Section 10. Prices, Joint Use and Salvage, Authorized Costs In Routine Operations and Equipment—

Pole prices and salvage for the various species permitted under specifications should be established by agreement, from time to time, from analysis of the costs obtained from the various utilities. Prices are usually fixed at the value of poles erected and ready for joint use in accordance with the specifications. Salvage values are net. It will be found that a large number of routine operations between utilities may be adjusted on a fixed cost basis obviating the necessity for keeping costs and rendering separate bills for minor transactions. Equipment may be handled in the same manner. An investigation into the construction and maintenance costs will provide satisfactory rates covering all phases of construction and reconstruction.

Section 11. Principles to Be Applied to Specific Transactions—

The utilities at interest determine the details of joint use in specific transactions in accordance with principles and practices of the contract. The specifications should closely follow code practice but it will be necessaary to supplement same with various provisions pertinent to such a contract. As such, the specifications should be set up as a separate part of the agreement. In general, all expenses involving a joint pole or line of poles are a joint expense and should be distributed equitably after a thorough investigation into the economic conditions governing construction and operating costs.

Section 12. Billing for Equities—

The owner or owners of pole to be used jointly with other utilities should be allowed to bill said utilities for the equity charges as determined by contract. Such bills should be due and payable as soon as the officials of parties to the contract have agreed to such joint ownership and poles have been put into condition as required and record completed.

Section 13. Relinquishments—

Any joint owner may relinquish its equity in joint poles and may be relieved of its obligations incident thereto. This requires proper notice in writing and the removal of its wires, cables and other property in accordance with the contract. Poles removed or relinquished shall be disposed of at salvage value between various utilities which are joint owners.

Section 14. Assignments—

In general, no utility to the agreement should be permitted to assign or otherwise dispose of its rights or equities under the agreement to any person, firm or corporation without the written consent of the other utilities or their successors at interest, except that nothing should limit the right of any party to the contract from making a lease sale, conveyance or assignment to all or part of its properties, privileges or franchises, or to enter into any consolidation with, or be succeeded by another utility or utilities in manner authorized and provided by law.

Section 15. Taxes and Assessments—

Each party should pay all taxes and assessments lawfully levied upon poles jointly owned in proportion to the joint interest therein.

Section 16. Clearance Arms and Service Wires—

It is not the practice to make a charge to parties to the contract for attachments to foreign poles when such attachments provide or maintain horizontal clearance from pole or wires only. Service wires may be attached to poles without charge in order to provide vertical clearance but the span length involving service should be limited.

Section 17. Guys and Anchors—

It is frequently the practice to permit guy wire attachments to existing poles, stubs and anchors without charge upon application in writing to the owner of such property. In new work, the practice is to set stubs and anchors at joint expense, each utility doing its own guying.

Section 18. Shares and Space on Jointly Owned Poles—

This type of contract is based on the principle of joint ownership in poles used and such ownership should be an undivided equity or interest. The relation between shares and space should be established from an economic study of the values involved, bearing in mind that a multiplicity of classifications of shares and space is not desirable, yet the situation demands an equitable division involving the maximum space for unlimited facilities and restricted space for limited facilities.

Section 19. Maintenance, Renewals or Removals of Joint Poles—

Maintenance on joint poles should be paid for by each utility in proportion to its joint ownership therein. Renewals or removals may be made at the request of any utility and all joint owners participate in the salvage on poles removed. Each utility transfers its own equipment in accordance with the principles governing the division of costs.

Section 20. Division of Costs—

Each joint transaction involves an equitable division of costs for the best engineering solution of the specific problem involved between the utilities at interest. This implies that any utility constructing or reconstructing a pole line for its own benefit with existing line should be held liable for the structural value of the existing line. In practice this may be stated more simply for certain specific cases.

Section 20.1. New Locations—

In new locations, constructing party upon request, sets poles sufficient for the use of all utilities desiring facilities at that location. Each utility participates in accordance with the contract, purchasing interest at prices fixed in the agreement.

Section 20.2. Rearrangement of Equipment on Existing Poles—

If existing pole is suitable for joint use but rearrangement of plant or equipment is necessary to make such joint use possible, then the party or parties desiring joint use, shall pay for the expense of such rearrangement. This should not include cost of minor changes such as service wires or clearance attachments which occupy the normal space of the incoming utility.

Section 20.3. Construction by Incoming Utility, One Pole Line Owned by One or More Utilities, or Replacement of Joint Pole Line For Benefit of One Joint Owner—

Where an existing pole line individually or jointly owned is not suitable for the equipment of an incoming utility or for increased facilities of one of the existing joint owners, the incoming utility or the joint owner increasing facilities, is obligated to replace existing poles with those suitable for all utilities requiring interest. Existing utilities may acquire interest in new poles on the basis of the structural value in the existing line. An arbitrary method for making such adjustments may be stated as follows:

(*a*) They may acquire equity on the basis of their salvage in existing poles and receive transfer cost. This may be recommended when existing poles are depreciated not more than 25 per cent in accordance with the joint pole schedule of depreciation.

(*b*) They may acquire equity by purchase at joint pole price and receive transfer cost and salvage existing property. This may be recommended where poles are depreciated more than 25 per cent but not more than 75 per cent in accordance with the joint pole schedule of depreciation.

(*c*) It is common practice to disregard existing structural value when poles are depreciated more than 75 per cent, in accordance with joint pole schedule of depreciation, in which case the existing utilities should be expected to purchase interest and pay own transfer costs and salvage existing equity in property.

All other incoming utilities may participate in joint use by sharing in the penalties attached thereto in a similar manner.

Section 20.4. Construction by Incoming Utility Where Two or More Pole Lines Exist, or Reconstruction by Incoming Utility Where Two or More Pole Lines Exist—

Where two or more pole lines exist and an incoming utility or one of the existing utilities desires new or increased facilities in the same location, said utility should set poles sufficient for the joint use of all utilities at this location. Each utility purchases interest from constructing utility and pays own transfer expense. Any other incoming utility may participate in the same manner.

Section 20.5. Vacation of Right-of-Way and Pole Location—

When one utility surrenders and vacates its line location to an incoming utility, the following principles apply: The incoming utility purchases the plant and associated right-of-way of the vacating utility at its structural value. The vacating plant constructs its plant in a suitable non-conflicting location at no expense to the incoming utility, except such additional expense as may be incurred in providing equivalent (but not increased) facilities, such as right-of-way or different type of construction necessitated by character of the new route. The incoming utility may dispose of plant purchased from vacating utility as it may elect, but if by agreement, part or all of this plant is resold to the vacating utility, the resale price should be equivalent to the net salvage value (gross salvage less cost of removal).

The same principles may be applied to obtain crossing clearances except that the equipment which is not removed may be excluded from the purchase price for the incoming utility and the cost to the incoming utility shall include the following items: structural value of existing poles, less net salvage, plus difference in cost of new poles installed in excess of cost of replacing existing poles for equivalent facilities plus the cost of transfer.

Section 21. Joint Planning.

All utilities should plan plant changes as far in advance as practicable and should notify other utilities of contemplated construction or reconstruction. They should co-operate to avoid conflicts to promote joint use or avoid use as the case may be, depending upon the conditions governing the conflict and the circuits involved. Each utility must determine the character of its own circuits and structures to be placed and continued in joint use and determine the character of the circuits and structures of others with which it will enter into and continue in joint use. In joint planning the principle of least cost for the most practical solution of the specific problem should apply.

PART II—SPECIFICATIONS FOR JOINT USE OF POLES FOR SUPPLY, TRANSMISSION, TRANSPORTATION AND COMMUNICATION UTILITIES

A general specification may be adopted for the joint use of poles. Possibly this is not desirable. To avoid practices which may be conflicting, it may be better to refer to State on other code used in the regulation of overhead construction, supplementing same with such features as are pertinent to local conditions. No attempt will be made herein to suggest a complete specification but a general classification of subjects which should be considered in connection with joint use are given herewith:

1. Scope and application.
2. Definitions.
3. Relative levels.
4. Grades of construction.
5. Vertical clearance.
6. Horizontal separations and clearances.
7. Vertical runs.
8. Communication cables or conductors on suspension strand.
9. Climbing space.
10. Fixtures and electric lamps.
11. Trolley span wires and brackets.
12. Pole steps.
13. Guys.
14. Guy insulators.
15. Line insulators.
16. Inductive co-ordination.
17. Loading.
18. Strength requirements.

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*Lightning Arresters**

The year's activity of the subcommittee on lightning arresters centered around discussion and the gathering of information covering the extent of system troubles and damage to apparatus due to lightning. The practices of the various companies regarding the installation of lightning arresters was studied and the desirability of obtaining adequate protection at a lower cost than has been possible in the past was emphasized.

The activities of the large manufacturing companies in regard to studies of lightning disturbances and development of new arresters is reviewed.

TO DETERMINE the necessity of lightning arresters on the systems of the various operating companies on the Pacific Coast, the subcommittee on this subject followed the plan of having the member companies submit a report on the service interruptions and damage to apparatus suffered as the result of lightning. Due to the geographical location of a number of the companies, their troubles due to lightning were so slight that there was very little damage to report. Other companies had a sufficient number of cases of trouble to justify the installation of arresters at their generating plants and substations. It appears desirable to use more arresters out on the distribution circuits, but it is questionable as to how much expense is justified in a territory which experiences only occasional lightning storms.

The San Joaquin Light & Power Corporation, The Southern Sierras Power Company, the Bureau of Power and Light of the City of Los Angeles, and the Southern California Edison Company each submitted a report on troubles due to lightning. This information is incorporated as part of this report. A map showing lightning hits on the system of the San Joaquin Light and Power Corporation is particularly interesting. Such a map shows clearly the portion of a system which experiences lightning disturbances and is recommended to the member companies as a means of making a study of their own systems to determine when lightning protection is justified.

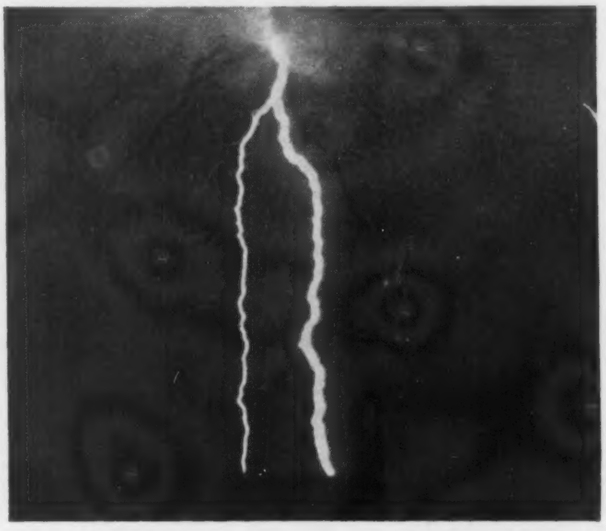

Fig. 1. Flash of lightning. Photograph courtesy of Westinghouse Electric and Manufacturing Company.

There is no question that the first consideration regarding protection of apparatus against transient high voltage disturbances is to design the apparatus with as high insulation as economically feasible. However, this practice has its very definite limits and it is generally agreed that the modern lightning arrester is the best device so far developed to handle these high voltage disturbances. The cost of lightning arresters, however, particularly for the higher voltages (66 kv. and above) is such that it is sometimes questionable to what extent their installation is justified, even though they are quite desirable and adequate for protection. In line with the general policy of using every effort to decrease the cost of installation and operation of all electrical equipment, the manufacturers have been urged to develop less expensive and at the same time reliable lightning arresters for the higher operating voltages. Progress has been made along this line during the past two years, two of the manufacturers placing lightning arresters on the market rated at voltages up to 73 kv. which cost considerably less than previous standard designs, and from all reports have been giving reliable and satisfactory service. Two designs of this less expensive form of arrester are shown in this report.

During the past few years there has been considerable activity in the study of lightning and considerable new information has been recently obtained. Equipment is now available which was unknown a few years ago. With such valuable tools as the Dufour oscillograph, the Klydonograph, and the Norinder oscillograph, the manufacturing and operating companies are working together so that soon we will have a definite knowledge of the nature of high voltage disturbances. As is always desirable, experimental facts are replacing theory and the industry will benefit accordingly.

Short statements from the manufacturers covering the activities of two of the large manufacturers in studying lightning and high voltage disturbances are submitted as part of this report.

The committee urges the operating companies to keep as detailed a record as practicable of lightning and high voltage

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* Report of subcommittee on lightning arresters, electrical apparatus committee, Engineering Section. E. R. Stauffacher, chairman. C. F. Benham, L. A. Buese, Fred Garrison, A. S. Glasgow, David Hall, J. M. Keith, B. N. Merritt, C. E. Schnell, P. J. Vogel.

disturbances on their respective systems. Further it is hoped that the research activities of the manufacturing companies will result in less expensive arresters and more definite knowledge as to how they may be applied to the greatest advantage.

Reports of Power Companies

The various power companies submit the following reports regarding their experiences and troubles due to lightning disturbances:

Extent of System Troubles and Damage—San Joaquin Light and Power Corporation[1]—

The subject of lightning disturbances was rather completely covered in the report of R. V. Hall of this company last year, and quoted in part in the committee report (page 350 Electrical West, May 15, 1928). Consequently the figures herewith submitted are for the year 1928.

It is interesting to note that there were two severe storms May 18 and 19, and December 10 and 12, and that some new territory other than reported in the three previous years was subjected to lightning.

Damage was experienced in seven substation yards, two of which were equipped with electrolytic arresters on one line only. No

[1] Prepared by C. E. Schnell.

TABLE I—Report of Disturbances for 1928

	110 kv.	70 kv.	30 kv.	Total
No. of disturbances, all causes, 1928.....	22	105	22	149
No. of disturbances, due to lightning, 1928	2	19	3	24

TABLE II—Lightning Disturbances 1925-1928

Year	Total Disturbances	Disturbances due to lightning	Per cent due to lightning
1925.....	301	41	13.6
1926.....	262	38	14.5
1927.....	211	13	6.1
1928.....	149	24	16.1

TABLE III—Failure of Distribution Transformers Due to Lightning

January 1st to October 31st, 1928

	Total Failures	Failures from Lightning	Per Cent Failures from Lightning	Failures from Lightning per 100 installed
January.....	20	3	..	0.0075
February.....	22	5	..	0.0124
March.....	14	9	..	0.0221
April.....	17	4	..	0.0097
May.....	48	28	..	0.0674
June.....	43	13	..	0.0309
July.....	23	6	..	0.0142
August.....	26	0	..	0
September.....	14	0	..	0
October.....	19	3	..	0.0022
Total.....	246	71	28.8 per cent	0.154

Total transformers installed..... 46,000

Loss due to lightning..... 71

Percentage loss due to lightning..... 0.154 per cent

Based on an average of 46,000 distribution transformers installed, the loss due to lightning is one transformer in 650 transformers. This is based on a ten month period. November and December figures are not available.

TABLE IV—Summary of Lightning Disturbances on Transmission System—110-kv.—70-kv.—30-kv. From Jan. 1st, 1928 to Dec. 31st, 1928.

Date	Duration of Line or Equipment Outage	Length of Service Interruption	Location of Trouble	Type of Construction	Extent of Damage	Approximate Cost of Repairs
110-kv. Lines						
May 18	23 min.....	1 min.....	Sanger-Corcoran No. 2.....	Steel.....	None.....	Patrol $25.00
May 19	None.....	None.....	Corcoran-Semi Tropic No. 1 Vertical corner.	Wood.....	Two overhead guys burned off. Six strain units damaged.....	Patrol $25.00 Material and Labor $80.00
70-kv. Lines						
Mar. 3	4 hr. 12 min.	1 min.....	Taft Substation.....	Steel.....	2 disconnect switch insulators and 5 strains damaged in 70-kv. yard. Arresters on 1 line into substation.....	$80.00
Apr. 3	10 min.....	Livingston, Los Banos & Ora Loma 10 min.	Merced-Livingston Line....	Wood-Suspension	None.....	None
May 18	1 min.....	1 min.....	Corcoran-Alpaugh Line....	Wood-Suspension	None.....	None
May 18	1 min.....	1 min.....	Corcoran-Alpaugh Line....	Wood-Suspension	None.....	None
May 18	1 min.....	1 min.....	Corcoran-Alpaugh Line....	Wood-Suspension	None.....	None
May 18	5 hr. 38 min.	Tulare Lake 14 min. Lakeside 2 hr. 13 min.	Henrietta-Tulare Lake.....	Wood-Pin.....	3 pin type insulators on 1 pole.....	$80.00
May 18	43 min.....	Corcoran 43 min. Alpaugh 2 min.	Corcoran Substation.....	Steel.....	Burned off transformer lead.....	$10.00
May 19	3 hr.....	None.....	Angiola Substation.....	Steel.....	Damaged potential transformer.....	$100.00
May 19	6 hr. 49 min.	Copper Mine 1 hr. 11 min. Madera & Dairyland 38 min.	Copper Mine Substation...	Steel.....	6 strains in bus and line switch. Arresters on 1 line into substation.....	$400.00
May 19	9 hr. 36 min.	16 min.....	Copper Mine-Kearney Line	Wood-Pin.....	Brought 1 phase down into 11-kv. line. Burned 3 phases enough to require replacement....	$100.00
May 19	7 hr.....	Copper Mine 17 min..	Copper Mine-Tivy Valley Line	Wood-Pin.....	Burned 1 and split 4 poles.....	$80.00
May 19	6 hr.....	1 min.....	Alpaugh Substation.....	Wood.....	Lead to potential transformer burned off and 70-kv transformer switch damaged.....	$50.00
May 19	None.....	None.....	Coalinga No. 1-Coalinga No. 2 line.....	Wood-Suspension	Guy and string of insulators damaged and conductor pitted.....	$100.00
May 19	None.....	None.....	Coalinga No. 1-San Miguel Line.....	Steel.....	String insulators damaged, pitted conductor..	$200.00
May 19	None.....	None.....	Coalinga No. 1-San Miguel Line.....	Wood-Pin.....	5 pin type insulators required replacement at 4 locations—arm burned.....	$150.00
May 20	1 min.....	1 min.....	Coalinga No. 1-Coalinga No. Line.....	Wood-Pin.....	No damage.....	.....
Dec. 10	1 hr. 50 min.	1 hr. 50 min.....	Calwa Ice Substation.....	Steel.....	Indoor transformer bushing flashed over. Transformer replaced with spare. Test later showed O.K. No damage.....	$25.00
Dec. 10	6 hr. 32 min.	None.....	Corcoran-Henrietta Line...	Wood-Suspension	2 bottom phases burned in two about 2 ft. from insulators. Third phase nearly burned in two. One suspension unit damaged.....	$80.00
Dec. 12	14 hr.....	1 hr. 17 min.....	Merced-San Joaquin Line...	Wood-Suspension	1 phase in two, other damaged. Pole burned in two and replaced. Adjacent pole flashed but no damage.....	$100.00
30-kv. Lines						
May 16	11 hr. 22 min.	Kittridge 39 min. Briceburg 49 min...	Merced River—Emory—Incline Line.....	Wood-Pin.....	Insulator and arm damaged.....	$150.00
May 19	1 min.....	1 min.....	Sugarpine Lumber Co.....	Wood-Pin.....	Consumers oxide film arresters damaged—Insulator flashover and shattered.....	.....
Dec. 12	Indefinite....	1 hr.....	Merced Falls Substation....	Steel.....	30-kv. winding 500-kva. transformer damaged two coils.....	$500.00

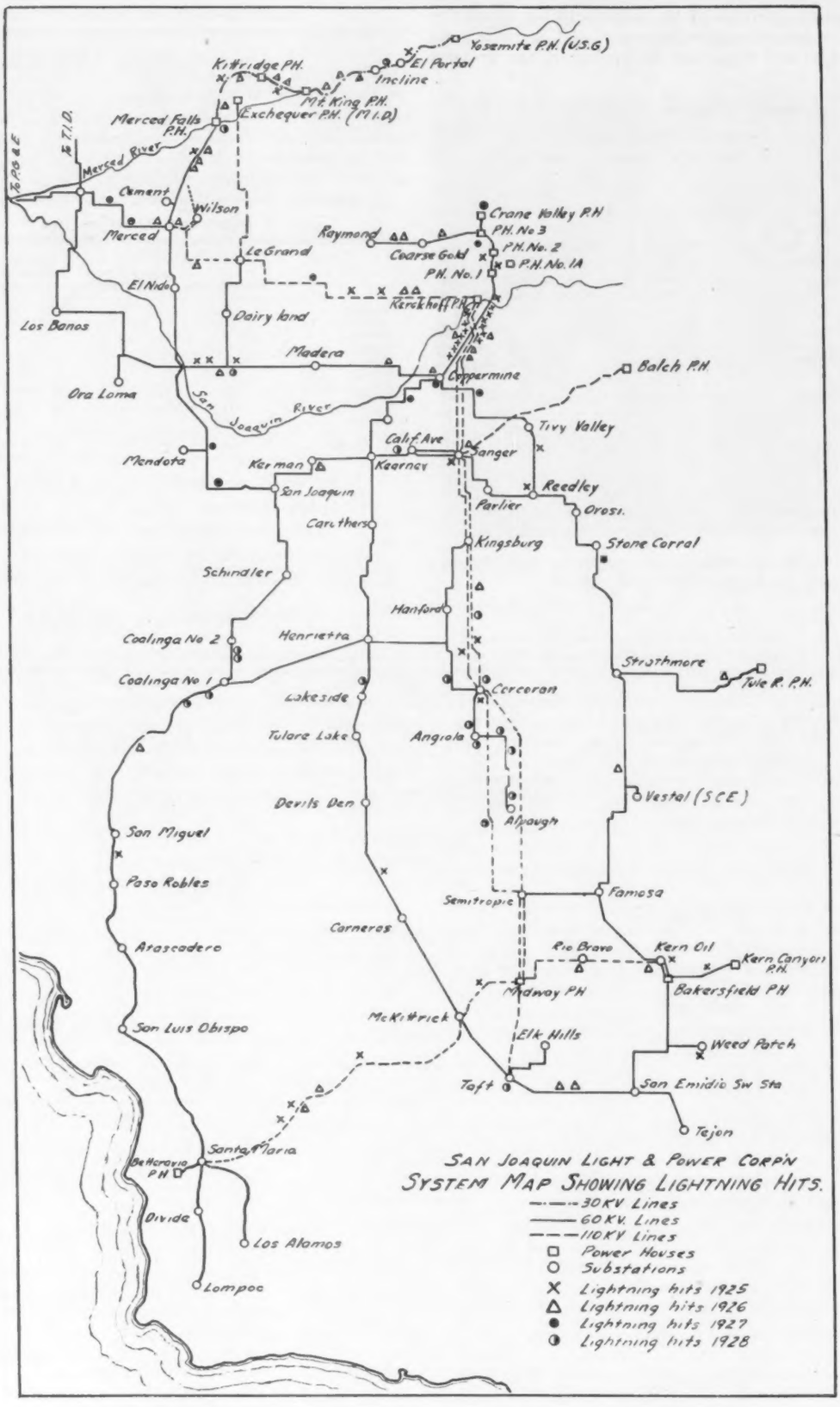

Fig. 2. System map, San Joaquin Light & Power Corporation, showing lightning hits.

arresters have been removed from service, however, at any substation. One 70-kv. oxide film arrester was added by a customer who went to the transmission rate this year, thus adding the only new arrester on the system. One customer experienced damage to the arrester protecting his substation. This was due to an insulator flashover which shattered. Service was interrupted about one minute. Whether the arrester performed properly is subject to debate but the other equipment was undamaged.

No actual segregated costs have been kept on the various repairs necessitated due to lightning, except at Copper Mine Substation. An attempt has been made to analyze the other as to patrol costs, labor and material repair costs.

Due to loop or parallel lines, the service interruption is usually shorter than the time of outage of the line or equipment, due to time of making repairs. This is indicated in column 2 and 3.

Arresters for Altitudes Above 2,000 Ft.—

Our company is no longer installing arresters except in special cases where the altitude is in excess of two thousand feet and lightning is known to be prevalent. This refers to small types for distribution transformers.

No Arrester Troubles—

There have been no troubles for the past year due to arresters.

It may be of interest to know that one of our dispatchers is responsible for keeping data on lightning disturbances. Operators at 29 locations throughout the system have instructions to report any indications of lightning, thus giving us a story of storms which often do no damage to the system. These reports show that on 23 days in 1928, lightning was observed.

Enclosed is also a tabulation of failures of distribution transformers due to lightning for the first ten months of 1928.

Considering the depreciation reserve set up at the time of lightning failure, the trade-in value of the junk transformers, the cost of replacement and other incidental costs, these transformers represent a loss of approximately $6,500. This represents interest on only a fraction of the total cost to protect adequately all our distribution transformers.

The map of transmission line hits submitted last year has been brought up to date and is included herewith. It is of interest to note that lightning has reached into new territory as well as making some repeat hits.

Lightning Arresters—The Southern Sierras Power Company—

It is this company's practice to install arresters for all voltages and capacities of stations, not universally but in sections seriously affected by lightning. High voltage stations are approximately 75 per cent protected at the present time. This includes the protection on 90-kv., 88-kv., 55-kv., and 33-kv. circuits. Various types of arresters are used with varying degrees of success. There have been practically no high voltage arrester failures and only a few low voltage arrester failures. The 15-kv., 4-kv., and 2,200-volt distribution substations are also generally protected by arresters on the various feeder circuits. It has been the company's experience that lightning arresters are a sound investment in the territory that it serves.

In one of the rural districts where the service is mainly for pumping and the lines are long, a large number of meters were lost annually due to lightning. The installation of small arresters has helped the situation some.

Where hydro-electric plants feed local distribution circuits from the station bus, such circuits are protected by means of a protective transformer bank in addition to arresters. This protective bank is normally a small one-to-one ratio transformer bank installed between the feeder and the station bus and has proven very effective in keeping lightning disturbances out of the station in case of arrester failure. Most of the hydro-electric plants are in districts much affected by lightning and in the past considerable property damage has resulted from lightning causes due to lack of complete protection.

Damage to apparatus and system troubles for the past year were considerably less than for previous years. The total interruptions to service for the year 1928 to date due to lightning causes are as follows:

TABLE V—Disturbances Caused by Lightning—Los Angeles Bureau of Power and Light System—May 16, 1922—September, 1928

Year	Date	Time	Location	Direct or Indirect Hit	Duration of Interruption Total System Outage H M S	Partial System Outage H M S	Equipment Damaged
1922	.....	.....	.....	.....	.....	.....	.....
1923	Apr. 18	12:48 p.m.	L. A. No. 11, 15-kv. lines	Indirect	... ..	0 — 1 — 0	No damage.
	Sept. 11	6:50 p.m.	N. Hollywood, 33-kv. line	Direct	... ..	0 —50 — 0	Burnt down 3 spans at Alessandro & Riverside Dr. Broke all insulators on P.T. switch No. 46.
	Oct. 31	4:43 p.m.	West 110-kv. line tower No. 189	Direct	0 — 3 — 0	.....	Shattered 1 string of insulators.
	Oct. 31	5:05 p.m.	West 110-kv. line, tower No. 189	Direct	0 — 1 — 0	.....	
1924	Feb. 9	3:09 p.m.	15-kv. line at Sheldon Ave	Direct	.....	8 —21 — 0	Transformer damaged at industrial station.
	Mar. 4	4:20 p.m.	West and Central San Pedro, 33-kv. lines at D. S. No. 4	Direct	.....	14—42 — 0	Oil switch at D. S. No. 4 blown up and roof bushings broken.
1925	June 5	1:44½ p.m.	110-kv. lines	Direct	0 — 9 —30	.....	Insulators broken at towers Nos. 234 and 237.
1926	Jan. 31	11:42 a.m.	Vernon lines relayed at L. A., No. 3 and Vernon, 15-kv. lines	Indirect	.....	0 — 1 — 0	Nothing damaged.
	Apr. 7	9:04½ a.m.	San Fernando-Roscoe line, 33-kv. line	Indirect	.....	0 — 2 — 0	Nine D. E. insulators broken between P. T. switch Nos. 560 and 561.
	Apr. 13	3:16 p.m.	San Fernando-Roscoe P. T. switch No. 540, 33-kv. line	Indirect	.....	0 —16 — 0	One switch and one string insulator broken at P. T. switch No. 540.
	Apr. 13	3:25 p.m.	River Power-Lankershim, 33-kv. line	Indirect	.....	0 —27 — 0	D. S. No. 35 out but no damage found.
	Apr. 13	4:03 p.m.	D. S. No. 14, 33-kv. line	Direct	.....	0 —10 — 0	Roof bushing broken and B-phase transformer burnt out.
	May 2	2:23 p.m.	Irolo-Longwood, 33-kv. line	Indirect	.....	0 — 5 — 0	Fiber bushing at D. S. No. 17-B burnt.
	May 2	2:45 p.m.	Hollywood-Irolo, 33-kv. line	Indirect	.....	0 — 7 — 0	No. 19 O.S. at D.S. No. 6 damaged. Leads burnt off.
	May 2	2:56½ p.m.	Hollywood-Franklin, 33-kv. line	Indirect	.....	5 —53 —30	O.S. bushings at Metropolitan Studios broken.
	May 2	3:15 p.m.	Hollywood-Franklin 33-kv. line	Indirect	.....	0 — 8 — 0	Oil switch bushings broken and hole burnt in tank at Franklin. Oil switch at Home Ice Company blew up.
	May 2	3:20 p.m.	P.H. No. 3—San Fernando-Roscoe 33-kv. line	Indirect	.....	8 —50 — 0	Oil switch bushings damaged at Boulevard Rock and Gravel Plant.
1927	Apr. 10	6:17 p.m.	P.T. switch No. 534—San Fernando-Van Nuys, 33-kv. line	Direct	.....	0 — 1 — 0	Insulators at P.T. switch No. 534 broken.
	Apr. 12	1:52 p.m.	D.S. No. 27-A—San Fernando-Van Nuys relayed 33-kv. line	Indirect	.....	0 — 5 — 0	No damage.
	Aug. 28	8:13 a.m.	Near P.H. No. 3 on 4,400-volt feeder	Indirect	.....	0 —13 — 0	4,400-volt equipment in P.H. No. 3.
	Dec. 10	5:20 p.m.	E. and W. Wilmington 33-kv. lines	Indirect	.....	0 — 0 —20	No damage.
	Dec. 10	5:21 p.m.	E. and W. Wilmington 33-kv. lines	Indirect	.....	0 — 0 —20	
	Dec. 10	5:21½ p.m.	E. and W. Wilmington 33-kv. lines	Indirect	.....	0 — 0 —20	
1928	Oct. 13	3:04 p.m.	San Fernando-Roscoe line	Direct	.....	0 — 4 — 0	No damage.
1929	Jan. 20	9:45 a.m.	D. S. No. 45-A	Direct	.....	0 — 1 — 0	Two transformers bushings broken. Regulator leads burnt off and motor damaged.
	Jan. 20	10:07 a.m.	R.S.C. system Wilmington-Menlo East and West lines	Direct	.....	0 — 1 — 0	Two dead end insulators broken on Wilmington-Menlo West line. Three 33-kv. wall bushings broken at D.S. No. 14.
	Jan. 20	10:24 a.m.	Alameda West and Slauson-Hyde Park line	Indirect	.....	0 — 0 —30	No damage.
	Apr. 4	9:06 a.m.	D.S. No. 28	Direct	.....	0 — 0 —30	Roof bushing. Six O.S. bushings.
	Apr. 4	9:11 a.m.	Franklin power plant	Direct	.....	0 — 7 — 0	Power plant put out of service.
	Apr. 4	9:18 a.m.	River power—Lankershim	Indirect	.....	0 — 2 — 0	Oil switch bushing broken at Hollywood Ice Co.
	Apr. 4	9:30 a.m.	Van Nuys-Roscoe line	Indirect	.....	0 — 1 — 0	Oil switch bushing broken at Crystal Springs.

90-kv. lines	18½ min.
88-kv. lines	33 min.
55-kv. lines	5 hr. 28 min.
33-kv. lines	3 hr. 5 min.

The 90-kv. and 88-kv. lines are the company's main supply lines from the hydro-electric plants in the north to the southern district. The 55-kv. lines are mostly in Nevada and are not as well protected with lightning arresters as the higher voltage lines.

The damage loss in transmission and distribution equipment for the same period has been confined entirely to secondary distribution transformers to the amount of approximately $1,000. Property

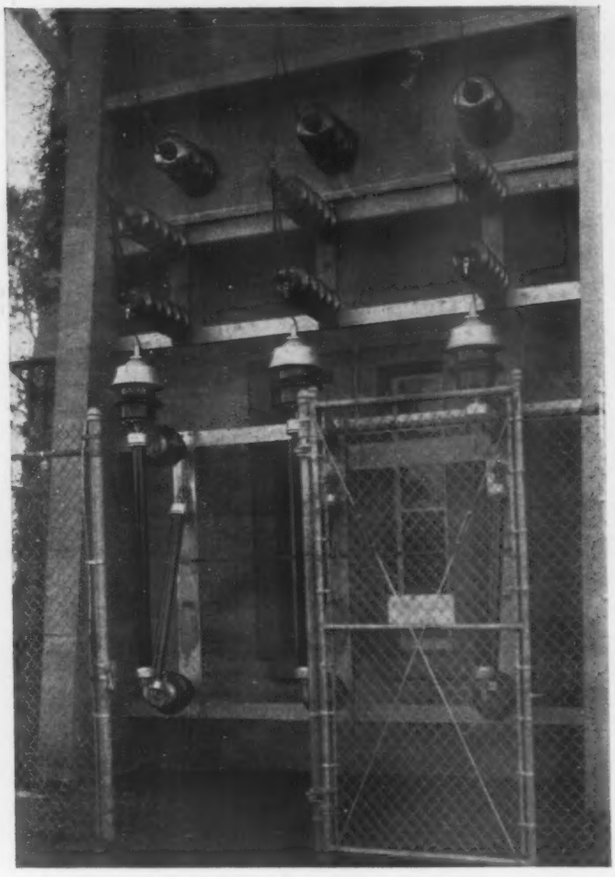

Fig. 3. 73-kv. pellet oxide film, San Fernando substation, Southern California Edison Company.

damage due to lightning in the year 1927 was approximately seven times as great.

Lightning arresters have caused some trouble and interruptions but none of serious consequences. The interruptions were caused because the arrester failed to prevent the interruption.

Lightning Disturbances—Los Angeles Bureau of Power and Light—

The disturbances shown in Table V are reported from the lines of the Los Angeles Bureau of Power and Light.

Lightning Disurbances—Southern California Edison Company—

A total of 753 cases of trouble on the lines of the Southern California Edison Company between the years 1924 and 1928 are reported as due to lightning, and probably an appreciable percentage of the 3319 cases of trouble where the cause was unknown were also due to lightning. Table VI covers this period.

Reports of Manufacturers

Westinghouse Field Experiments[2]*—*

To obtain first hand experimental information in the field the Westinghouse Electric & Manufacturing Company has set up portable recording oscillograph equipment at locations in Tennessee and New Jersey. During the summer of 1928 it was successful in obtaining a record of a direct stroke, and since that time quite a number of additional records have been obtained.

As a result of these tests the information concerning lightning and high voltage surges is expanding, and in a few years there is no doubt that much more will be known regarding methods of handling such surges.

The attached photographs show the experimental equipment set up along a transmission line in Tennessee.

General Electric Surge Voltage Tests on Transmission Lines[3]*—*

The first important step in the study of lightning was the perfection of the lightning generator. This device had been

[2] Prepared for the subcommittee on lightning arresters by the Westinghouse Company.

[3] Prepared for the subcommittee on lightning arresters by the General Electric Company.

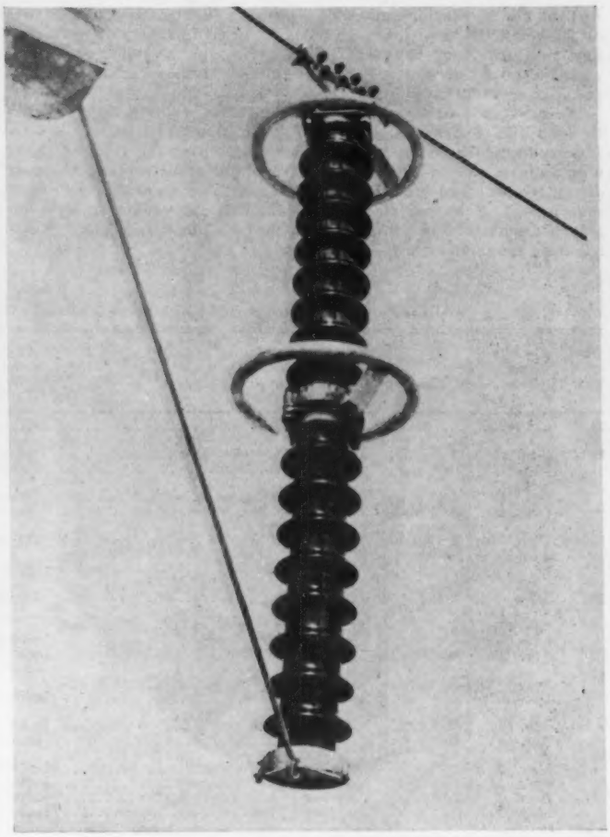

Fig. 4. Westinghouse high voltage auto valve line type arresters.

TABLE VI—Lightning Disturbances

Southern California Edison Company

Year	Voltage of Circuit-kv. 220	150	66	33	16	11	Unknown	Total Lightning
1924	...	...	9	5	25	24	830	63
1925	...	...	29	6	6	90	686	131
1926	...	...	49	18	48	246	771	361
1927	...	...	12	..	6	47	585	65
1928	6	...	20	..	10	97	447	133
	6	0	109	29	95	494	3,319	753

Total of 753 cases of trouble due to lightning.

Of the unknown cases (3,319) no doubt an appreciable percentage of which were due to lightning.

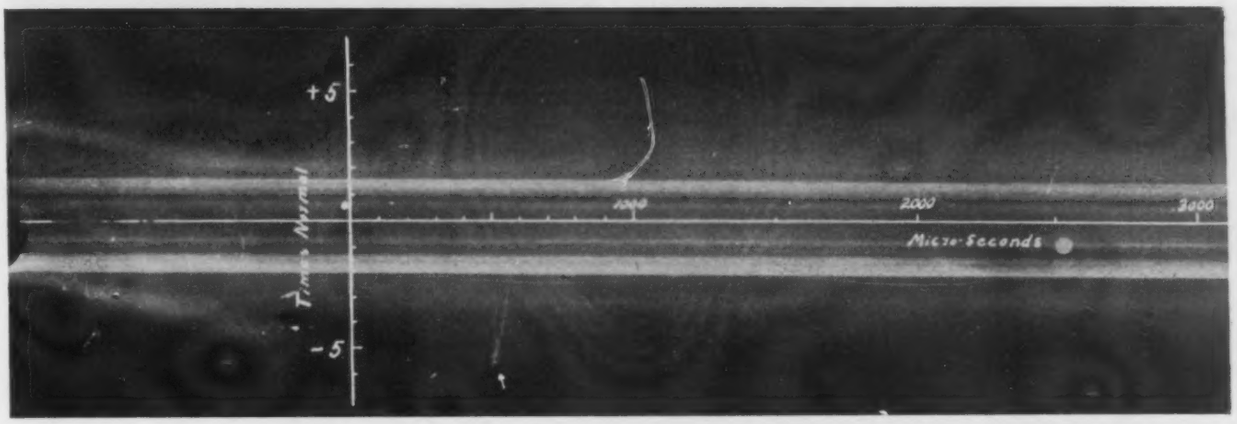

Fig. 5. Record of Norinder oscillograph, direct stroke on transmission line. Negative surge amounts to 5½ times normal. Surge apparently lasts from 10 to 20 micro-seconds.

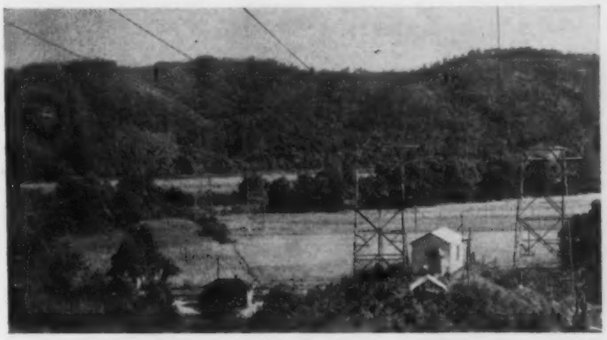

Fig 6. Shack at tower No. 70, location of Norinder oscillograph.

Fig. 7. Chilhower Mountains from tower No. 65 with shack at tower No. 70 in distance.

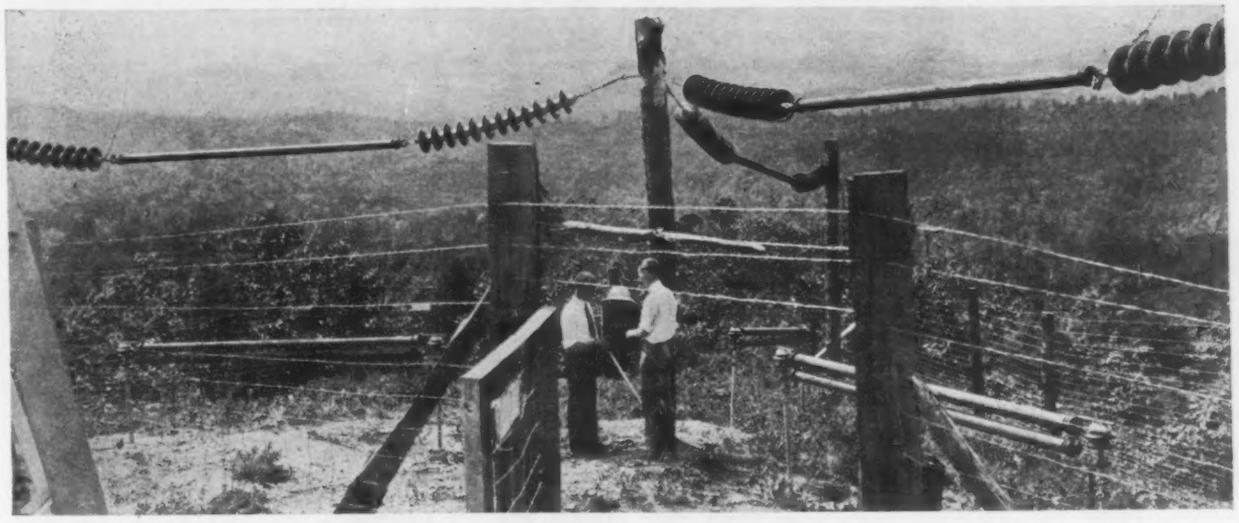

Fig. 8. Coupling equipment for Norinder oscillograph.

Fig. 9. Norinder oscillograph in place.

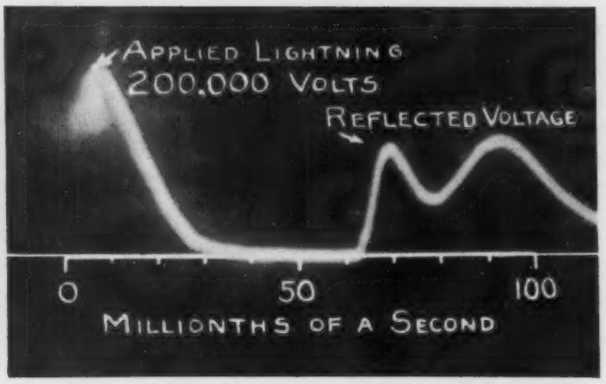

Fig. 11. 220-kv. applied at Pittsfield traveled to the open end of the line about six miles away, was reflected, and the reflected wave is shown on the same photograph.

used for a good many years but a design capable of giving high voltage and a large amount of power was perfected under Dr. Steinmetz's direction and opened the way for the first thorough and careful study of the effect of lightning arresters and other apparatus. Voltages as high as 3,600,000 have been used in tests by this piece of apparatus. The lightning generator, however, has two serious limitations—only the maximum voltage across the apparatus can be determined, and no information is given whatever in regard to the important element of time.

The technique of applying the cathode-ray oscillograph to the study of short-time transients was then perfected with the result that this instrument, in conjunction with the lightning generator, widely extended our knowledge in regard to the effect of artificial lightning disturbances on apparatus. With this instrument the three important characteristics of

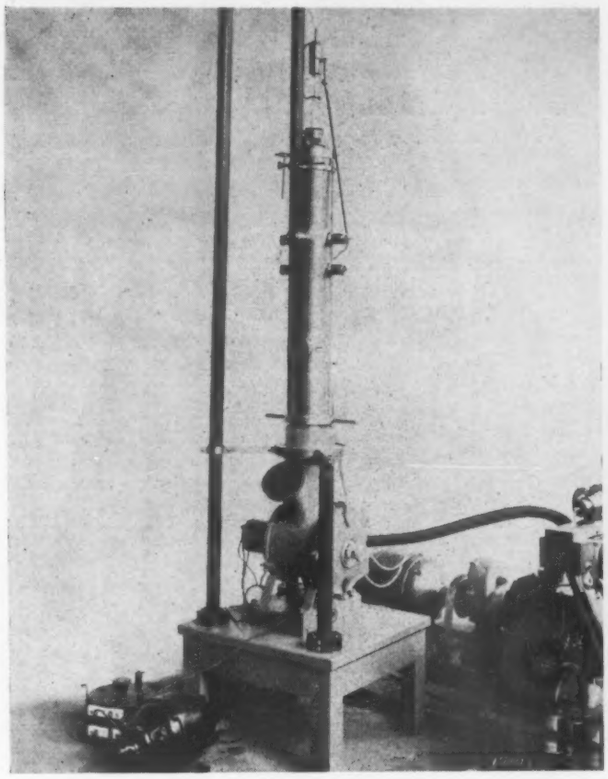

Fig. 10. Norinder oscillograph.

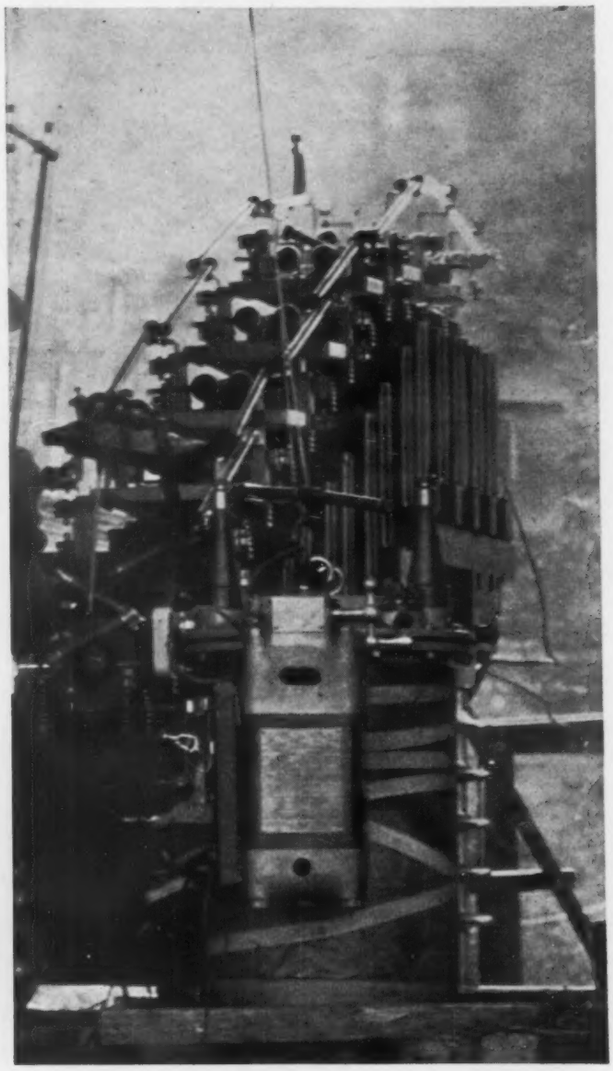

Fig. 12. Equipment for cathode-ray oscillographic study of surges on transmission line from Turners Falls to Pittsfield, Mass. Portable impulse generator for applying surge voltage to transmission lines.

a transient current, time, and voltage, could be shown with extreme accuracy.

The next important step in the search for knowledge about lightning was the study of voltages on transmission lines by means of surge voltage recorders. This further advanced our knowledge in that it told something about the magnitude and character of surges on transmission lines.

Last summer an actual photograph was taken by means of the cathode-ray oscillograph of a lightning surge, measuring about 2,500,000 volts, on the lines of the Pennsylvania Power & Light Company.

While these experiments were being conducted, the Pittsfield engineers realized that actual photographs of lightning were interesting and valuable but that a study of the effects of the actual lightning disturbances was too uncertain and would require too long a time in order rapidly to advance the study of lightning. They also knew that the transmission line itself would have an effect on the surge and as the characteristics of the original lightning surge would not be known there was needed some means of studying the effects of a known surge on apparatus connected to an actual transmission line. Permission was therefore secured from the Turners Falls Power Company to put artificial lightning disturbances on the transmission line (66-kv. line insulated for 110 kv.) running into Pittsfield, and a portable lightning generator was built so that this could readily be done. This lightning generator could be cut into the line at various points where disconnecting switches had been installed by the power company and a second lightning generator was installed at the substation in Pittsfield, where also was located a cathode-ray oscillograph and sphere gaps for recording and otherwise measuring the surges that were produced. The actual work was started late in the summer and has been continued practically every Sunday since, the line being killed by the power company so that the tests could be made.

Most of the tests so far have been performed at voltages up to 400,000 and these have been applied either at the substation end or from the portable lightning generator at a point approximately 6½ miles from Pittsfield. The surge can be put on the line at either end and the original surge with its reflections measured at the Pittsfield end.

Interesting data have been obtained on reflection, the effect of attenuation, and the operation of lightning arresters installed at Pittsfield. This work will be continued and extended to include various types of high voltage apparatus. Fig. 11 shows one kind of a record that can be obtained from these tests. In this case a voltage of 200,000 was applied at Pittsfield, traveled to the open end of the line about six miles away, was reflected, and the reflected wave is shown on the same picture as the original wave. The effect of attenuation is also indicated on this print. The second hump in the reflected wave is probably due to the effect of the condensers of the lightning generator at the far end of the line. A similar photograph has been taken where the gap sparks over at the far end of the line and the reflected voltage is exactly as shown on this print, excepting that it is below the line, that is, negative.

Complete account of these interesting tests was given by K. B. McEachron of the General Electric Company at the A.I.E.E. meeting in Cincinnati in March.

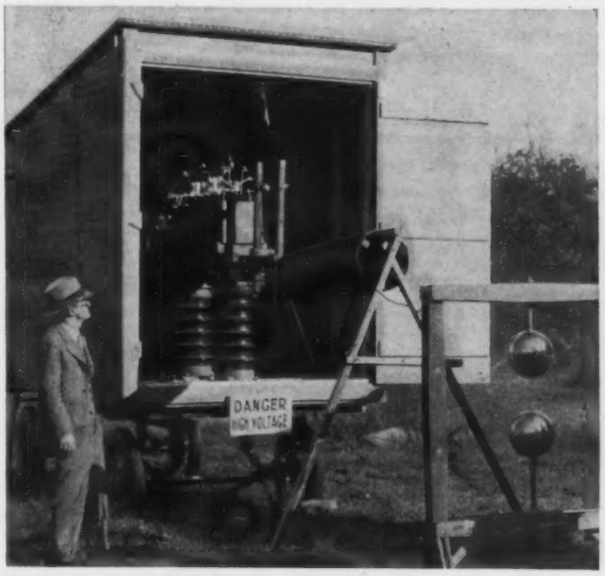

Fig. 13. Equipment for cathode-ray oscillographic study of surges on transmission lines, second view.

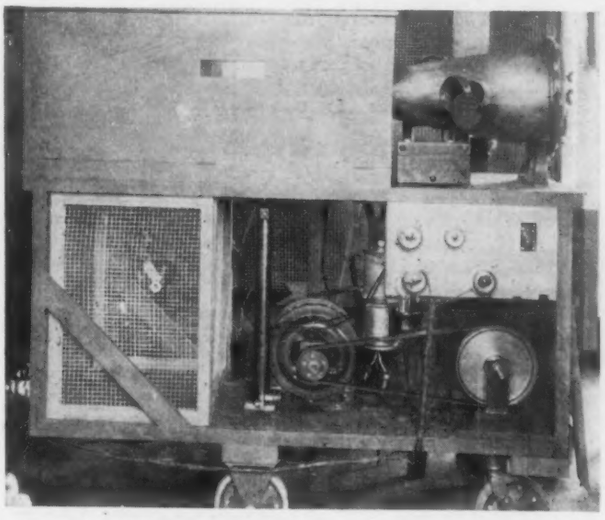

Fig. 14. Cathode-ray oscillograph and auxiliaries in Pittsfield Electric Company's substation.

*National Electrical Safety Code**

The function of this committee is to study the code and to point out wherein amendment or clarification should be considered. The committee has no unanimous recommendations to make at this time, but it is hoped that the results of the study will promote a further discussion, particularly with reference to grades of construction and loadings. Particular attention should be given to an analysis of failures or accidents of any nature which may be directly chargeable to inherent defects in construction standards. This study has been confined to that portion of part two of the code, dealing with overhead construction rules for supply and communication lines. That dealing with rules for underground construction and the so-called operating code, part four, will form the background for future code studies.

* Progress report of subcommittee on national electrical code, overhead systems committee, Engineering Section. J. E. Macdonald, chairman. K. B. Ayres, H. L. Caldwell, D. I. Cone, L. J. Corbett, R. R. Cowles, Geo. H. Hagar, R. E. Hill, J. B. Madden, C. T. Mess, H. H. Minor, E. R. Northmore, G. E. Nott, E. Y. Porter, W. E. Row, T. W. Snell, W. R. Van Bokkelen.

In dealing with code practices, the committee has been confronted by comparisons with General Order 64-A of the Railroad Commission of the State of California, which is largely responsible for the high standards of construction in this state. Some committee members are opposed to the national code in principle, others things being equal. They consider state supervision and state standards preferable to national standards for the development of the art. It is contended that the national code is more of a specification rather than a statement of principles, supported by adequate mechanical data.

Grades of Construction

THE theory upon which grades of construction are based assumes that overhead lines are located in zones of relative hazards, increasing with the voltage of the line and other circuits or structures involved. A change in grade of construction is required to meet increased hazards, the method being to increase the mechanical strength. In order to obtain a correct perspective this should be stated in terms of safety factor.

The committee is indebted to C. T. Mess of the Railroad Commission for certain valuable tables which make the two codes comparable. In General Order 64-A there are four grades of construction specified, which correspond to four different degrees of hazard recognized with corresponding gradation in the minimum construction standards. These grades are designated A, B, C, and F, grade A being the highest and grade F the lowest, which applies to communication and signal circuits under normal conditions. The same fundamental theory has been applied in the formulation of grades in the National Electric Safety Code. Grades A, B, C and N correspond in a general way to A, B, C and F of General Order 64-A. In the national code two additional grades are added, namely D and E, which apply to communication lines under special conditions. An economic study should be made of grades D and E to determine their value as code principles. For supply lines the voltage determines the class of circuits in both cases, and each class has its corresponding grade of construction under normal conditions. The national code makes a distinction between a conductor conflict and structure conflict, resulting in a different grade of construction, whereas General Order 64-A

TABLE 1—Summary Comparison Sheet of Grades of Construction

Circuit At Upper Level	Other Facilities Involved at Lower Level — Line Conductors in Urban Territory															
	0-750		750-5000		5000-7500		Over 7500		Major Comm.		Minor Comm.		Major R.R.		Minor R.O.	
	Code	G.O. 64-A	Code	G.O. 64-A	Code	G.O. 64-A	Code	G.O. 64-A	Code	G.O. 64-A	Code	G.O. 64-A	Code	G.O. 64-A	Code	G.O. 64-A
Supply Conductors,																
Open wire, 0- 750 volts	N	C	C	C	C	C	B	C	N	C	N	C	A	A	B	B
Open wire, 750-5000 volts	C	C	C	C	C	C	B	C	C	C	C	C	A	A	B	B
Open wire, 5000-7500 volts	C	B	C	B	C	B	B	B	B	A	C	B	A	A	B	B
Open wire, exceeding 7500 volts	B	B	B	B	B	B	B	B	A	A	B	B	A	A	B	B
(1) Cables, 0- 750 volts	N	C	C	C	C	C	B	C	N	C	N	C	A	C	B	C
Cables 750-5000 volts	N	C	C	C	C	C	B	C	C	C	C	C	A	C	B	C
Cables 5000-7500 volts	N	C	C	C	C	C	B	C	C	C	C	C	A	C	B	C
Cables, exceeding 7500 volts	C	C	C	C	C	C	C	C	C	C	C	C	A	C	B	C
Communication Conductors,																
Open wire or cables—Major	N	F	C	C	B	A	A	A	N	F	N	F	D	B	D	B
Open wire or cables—Minor	N	F	C	C	C(2)	B	B	B	N	F	N	F	E	F	E	F

Note.—(1) Properly bonded and grounded.

(2) Same size as required for supply conductors.

TABLE 2—Summary Comparison Sheet of Elements of Line

(Values in terms of Safety Factors unless otherwise noted)

Stresses	Grade of Construction	(1) Poles (5000-lb.)		Cross Arms (2)		Pins and Fastenings		Tie Wires		Guy Wires	
		Code	G.O. 64-A	Code	G.O. 64-A	Code	G.O. 64-A	Code	G.O. 64-A	Code	G.O. 64-A
Longitudinal—balanced	A-B	700 lb.	700 lb.	700 lb.	700 lb.	700 lb.(4)	700 lb.(5)	700 lb.(4)	500 lb.(4)	1.0	2.0
Longitudinal—balanced	C	700 lb.	700 lb.	700 lb.	700 lb.	700 lb.(4)	700 lb.(5)	700 lb.(4)	500 lb.(4)	...	2.0
Longitudinal—balanced	D	2.0(6)	...	Note 7	...	Size	...	...	...	Note 8	...
Longitudinal—balanced	E	1.3(6)	...	Note 7	...	Size	...	...	...	Note 8	...
Longitudinal—balanced	F(13)	...	1.0(8)	...	Note 9	...	1.0	...	500 lb.(4)	...	Note 8
Longitudinal—balanced	N(13)	Gen'l.	...	Gen'l.	...	...	...	...	...	Gen'l.	...
Longitudinal—end supports at crossings	A-B	1.0(10)	1.0(10)	1.0(10)	1.0(10)	1.0	1.0	1.0	500 lb.(4)	1.0	2.0(10)
Longitudinal—end supports at crossings	C	700 lb.	700 lb.	700 lb.	700 lb.	700 lb.(4)	700 lb.(5)	700 lb.(4)	500 lb.(4)	...	...
Longitudinal—section of change of grade	A-B	1.0	1.0	1.0(11)	1.0(11)	1.0	1.0	700 lb.(4)	500 lb.(4)	...	...
Longitudinal—section of change of grade	C	700 lb.	1.0	700 lb.	1.0(11)	700 lb.	1.0	700 lb.(4)	500 lb.(4)	...	...
Longitudinal—dead ends and angles	A	3.0	4.0	1.0(11)	2.0(11)	...	2.0	...	...	2.0	2.0
Longitudinal—dead ends and angles	B	2.0	3.0	1.0(11)	2.0(11)	...	2.0	...	...	2.0	2.0
Longitudinal—dead ends and angles	C	1.3	2.0	None	2.0(11)	...	2.0	...	...	1.3	2.0
Transverse	A	3.0(12)	4.0(12)	...	...	...	2.0	...	...	2.0	2.0
Transverse	B	2.0(12)	3.0(12)	...	...	...	2.0	...	...	2.0	2.0
Transverse	C	1.3(12)	2.0(12)	...	...	...	2.0	...	...	1.3	2.0
Transverse	D	4.0(6)	...	...	...	...	...	...	...	2.0	...
Transverse	E	2.6(6)	...	...	...	...	...	...	...	1.3	...
Transverse	F(13)	...	1.0	...	1.0	...	1.0	...	...	...	1.25
Transverse	N(13)	Gen'l.	...	Gen'l.	...	...	...	...	...	Gen'l.	...
Vertical	A-B-C	Note 14	Note 15	2.0(16)	2.0(15)	...	...	...	...	...	...
Vertical	D-E	Note 14	...	Note 17	...	...	...	...	...	...	...
Vertical	F(13)	...	Note 15	...	1.0(15)	...	...	...	...	...	...
Vertical	N(13)	Gen'l.	...	Note 16	...	...	...	...	...	Gen'l.	...

(1) Minimum top diameter of poles for grades A-B-C- are same in both codes. Minimum top diameter of poles for grades D & E of N. E. Code greater than grade F of G.O. 64-A.
(2) A slight variation in cross sections, depending on number of conductors supported.
(3) Minimum size of strand specified.
(4) As a maximum.
(5) As a minimum.
(6) For poles not carrying more than 2 wires, max. span 125 feet, min. top diameters specified.
(7) Minimum cross section—Double cross arms on crossing poles with limit of 10 conductors.
(8) Special table for various conditions.
(9) Minimum cross sections.
(10) Unbalanced tension equal to one-third total number of conductors.
(11) For conductor tensions of 2,000 pounds maximum, double cross arms meet strength requirements.
(12) Heavy loading areas assume two-thirds total number conductors with 10" as minimum.
(13) Other than crossings, conflicts and joint use.
(14) Total dead weight loading plus 225 pounds.
(15) Total dead weight loading plus 200 pounds.
(16) 225 pounds in addition to weight of conductors.
(17) Minimum cross section—Double arms on crossing poles, conductors limited to 10.

TABLE 3—Summary Comparison Sheet of Line Conductors and Messengers

	Loading District	Grade of Construction	150 ft. Span		300 ft. Span		Safety Factor	
			Code	G.O. 64-A	Code	G.O. 64-A	Code	G.O. 64-A
	Heavy	A	6	6	4	4(1)	2.0	2.0
	Heavy	B	6	6	4	4(1)	2.0	2.0
	Heavy	C	8	6	4	4(1)	1.6	2.0
	Heavy	D	9	..	9(2)	..	1.0	..
	Heavy	E	10	..	10(2)	..	1.0	..
	Heavy	F	..	12(3)	..	12(3)	..	1.0
	Heavy	N(4)	8	..	8	..	None	..
	Light	A	6	6	4	6	2.0	2.0
	Light	B	8	6	4	6	2.0	2.0
	Light	C	8	8	4	6	1.6	2.0
	Light	D	9	..	9(2)	..	1.0	..
	Light	E	10	..	10(2)	..	1.0	..
	Light	F	..	12(3)	..	12(2-3)	..	1.0
	Light	N(4)	8	..	8	..	None	..
Paired conductors	All	A-B	Note (5)	Note (5)	Note (5)	Note (5)	..	..
Paired conductors	All	C	14(6)	Note (5)	14(6)	Note (5)	..	..
(at crossings)	All	D-E	14(6)	..	14(6)	..	..	..
(at crossings)	All	F	..	14(7)	..	14(7)	..	..
(at crossings)	All	N(4)	None	..	None	..	..	..
Messengers (10)	All	A-B	2.0(8)	Note (9)	2.0(8)	Note (9)	2.0	1.9(11)
(steel strand)	All	C	1.6(8)	Note (9)	1.6(8)	Note (9)	1.6	1.9(11)
(steel strand)	All	D	2.0(8)	..	2.0(8)	..	2.0	..
(steel strand)	All	F	..	Note (9)	..	Note (9)	..	1.9(11)

Note.—A.W.G. hard drawn copper conductors.

(1) Preferably stranded.
(2) Increased sag or larger size conductor.
(3) For crossing railroads No. 10 as a minimum.
(4) Apply to supply lines—No requirements for communication conductors.
(5) Not supported by messengers—For grades A and B crossing supply conductors same size as line conductors of similar grade is required.
(6) Limited span lengths without messenger.
(7) Messenger construction required.
(8) These values are in terms of safety factors.
(9) Values for ultimate and safe working tension set forth in tabular form.
(10) The breaking strength set forth in code is approximately 12% less than that of G.O. 64-A.
(11) Average for conductor cables weighing between 2.25 pounds to 8 pounds per foot.

implies that existing hazards apply to all parts of line where possibility of contact exists from overturning of same. The national code assumes that hazard for circuit is not so great in rural as in urban districts and corresponding reductions of grade for rural districts are effective. Table 1 shows a comparison sheet of grades of construction; Table 2 the elements of line in terms of safety factors, unless otherwise noted; Table 3 is a comparison sheet of line conductors and messengers.

By referring to these tables it will be noted that the two codes are in close agreement. The following differences, however, should be noted:

The grades of construction required for supply conductors in cables (properly bonded and grounded) crossing major and minor railroads are higher in the National Electrical Code than those in General Order 64-A.

A higher grade of construction is required for open wire supply circuits of 5,000-7,500 volts crossing over wire supply circuits of 0-7,500 volts and communication circuits in General Order 64-A than in the National Electrical Code.

A higher grade of construction is required in General Order 64-A for communication conductors crossing over open wire supply conductors of 5,000-7,500 volts than that required in the National Electrical Code.

In the National Electrical Code a higher grade of construction is required for supply conductors (in cables) of 0-7,500 volts crossing open wire supply conductors in excess of 7,500 volts to that required in General Order 64-A.

In the National Electrical Code a higher grade of construction is required for supply conductors (in cables) of 0-7,500 volts crossing open wire supply conductors in excess of 7,500 volts than where conductors (in cables) in excess of 7,500 volts cross open wire conductors of the higher voltage. It appears rather inconsistent for the higher voltage classification to take the lower grade of construction.

For grades A, B and C the safety factors on structures and crossarms, required in General Order 64-A for longitudinal (dead ends and angles) and transverse stresses are greater than those of the National Electrical Code.

For vertical loadings on structures in National Electrical Code, the total dead weight loading plus 225 lb. is assumed, while in General Order 64-A only an additional weight of 200 lb. is included.

For vertical loadings on crossarms the weight of conductors plus 225 lb. is assumed in National Electrical Code, while in General Order 64-A the total weight of conductors, pins, insulators, hardware, plus 200 lb. is included.

In grade C for heavy loading districts and in grade B for light loading districts, the spans being not greater than 150 ft., a No. 6 A.W.G. hard drawn copper conductor as a minimum is required in General Order 64-A, while a No. 8 is the minimum size set forth in the National Electrical Code.

In light loading districts for grade A, B and C in spans of 300 ft., a No. 4 A.W.G. hard drawn copper conductor as a minimum is required in the National Electrical Code while a No. 6 is the minimum size set forth in General Order No. 64-A.

In the National Electrical Code double crossarms with designated minimum cross section are required on crossing poles in D and E grades of construction with a limitation of 10 conductors. In General Order 64-A no limitation is placed on the number of conductors provided the safety factors are met.

Loadings

Table 4 shows comparison of loadings of National Electrical Safety Code and General Order 64-A.

The classification of loadings in the National Electrical Safety Code and General Order 64-A have both been determined from data supplied by the United States Weather Bureau. In both cases arbitrary decisions were made in the selection of the allowable wind pressure for various loadings. This requires further study to determine if the differences between the two codes may not be co-ordinated by a compromise which will be satisfactory to all parties. It should be noted that in the third edition of the national code, the ratio of loadings to those of the California code was in some cases 3 to 1. In the fourth edition this has been re-

TABLE IV—Loading Definitions

	N.E.S.C.			G.O. 64-A		
	Ice	Wind	Temperature	Ice	Wind	Temperature
Heavy	½ in.	8 lbs.	0°F.	½ in.	6 lbs.	0°F.
Medium	¼ in.	8 lbs.	15°F.	No. medium loading		
Light	0	12 lbs.	30°F.	0	8 lbs.	25°F.

duced to about 1½ to 1. The difference in the larger size conductors is not so great because both loadings are approaching the dead weight of the condutcor. National code loadings make for greater sags than are necessary for California conditions. The greater sags offer an additional safety factor for conductor and conductor fastenings, but in many cases are the cause of short circuits unless conductor spacings are increased.

TABLE V—Relative Loadings for Sag Determination—Light Loading

Conductor Size	Diameter Inches	Conductor Weight Per 100 Feet	Resultant Loading Pounds N.E.S.C.	Per 100 Feet G.O. 64-A
4/0*.....	.522	65.3	83.4	74.0
3/0*.....	.464	51.8	69.3	60.3
2/0*.....	.414	41.1	58.2	49.5
No. 0**.....	.325	32.0	45.6	38.6
No. 1**.....	.289	25.3	38.4	31.8
No. 2**.....	.258	20.1	32.7	26.5
No. 4**.....	.204	12.6	24.0	18.5
No. 6**.....	.162	7.9	18.0	13.4
No. 8**.....	.128	5.0	13.7	9.8

*Stranded bare.
**Solid bare.

Table 5 shows existing loadings for sag determination in light loading districts in accordance with physical data of Table 4.

Conclusions

In order to accomplish effectively the purpose of this study, an increased effort will be necessaary to interest the California utilities in the national code. There is little doubt that the principles of General Order 64-A and the National Electrical Safety Code are approaching coincidence. The complexity of detail involved in the grades of construction in the national code requires an intimate analysis and an economic study, which this committee has not been prepared to undertake. The result is that the power utilities have been rather inclined to recommend a reversion to principles only in whatever code revision is undertaken.

*Operating Records on Overhead Lines**

When the suggestion was made that a subcommittee might with profit make a study of the operating conditions of overhead lines, it was with the thought in mind that such a study would be of material assistance to the member companies in determining the cause of circuit interruptions. If accurate records are kept of the causes of circuit interruptions and these records analyzed, it is possible to correct the conditions in a great majority of cases so that service can be rendered more economically from the company's standpoint and with less inconvenience to the consumer. Studying this subject, it has been found that there is a lack of accurate interruption reports, although some of the operating companies are following this matter very closely and have shown some very gratifying results from an operating standpoint as compared with the records of past years.

THE classification and tabulations included in this report bring out a number of very interesting and important facts which will emphasize the value of keeping records on line interruptions. We have not endeavored to analyze all distribution and transmission lines, but have selected a number and are reporting on these lines over a period from 1923 to 1928, inclusive, in order to get a representative number of cases of trouble and determine the trend of troubles and interruptions. We have analyzed a total of 12,780 cases of trouble, of which 77 per cent fall in the distribution classifications, and 23 per cent in the transmission classifications, the dividing line being taken at 20,000 volts. Of the 12,780 cases investigated, 3,050 could not be charged against distribution or transmission lines. This would leave 9,730 cases, 8,200 of this number being distribution trouble and 1,530 cases transmission trouble.

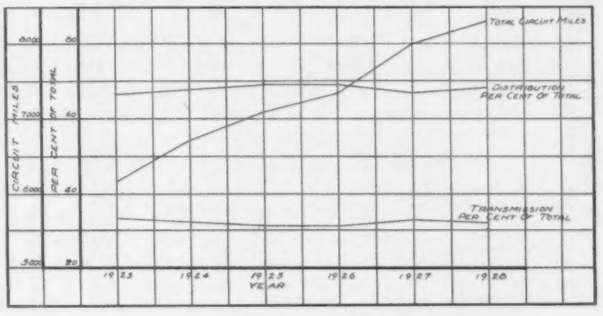

Fig. 1. System circuit miles.

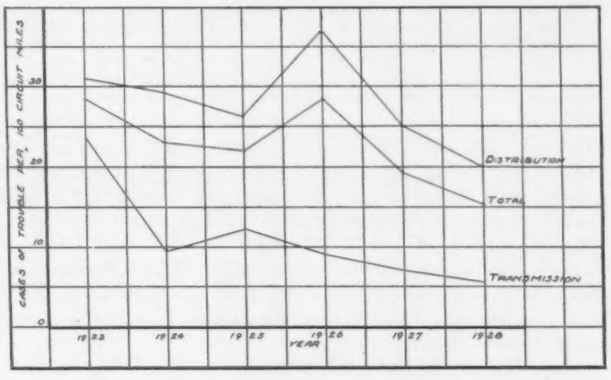

Fig. 2. Trend of cases of trouble per 100 circuit miles of line.

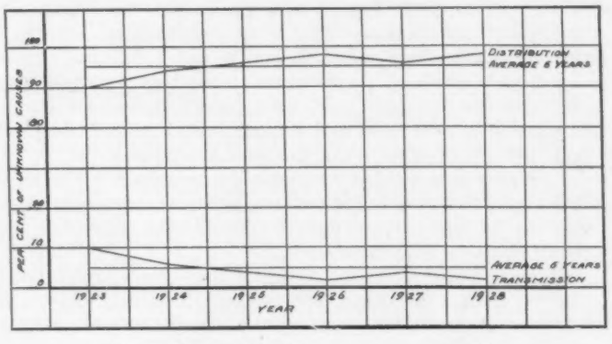

Fig. 3. Trend of unknown cases of trouble.

The circuits considered in this study have increased from 6,155 circuit miles in 1923 to 8,280 circuit miles in 1928, or an increase of 35 per cent. This is shown graphically by curves in Fig. 1. The total overhead interruptions per circuit mile of line have shown a consistent decrease from 28 cases per 100 circuit miles in 1923 to 16 cases per circuit mile in 1928, with the exception of the year 1926 when the cases

* Report of subcommittee on operating methods, overhead systems commitee, Engineering Section. R. G. Boyles, chairman. K. B. Ayres, F. D. Beardsley, C. S. King, G. A. MacDonald, D. D. Smalley, H. W. Tice, J. O. Tobey, H. B. Wells, G. M. Wills.

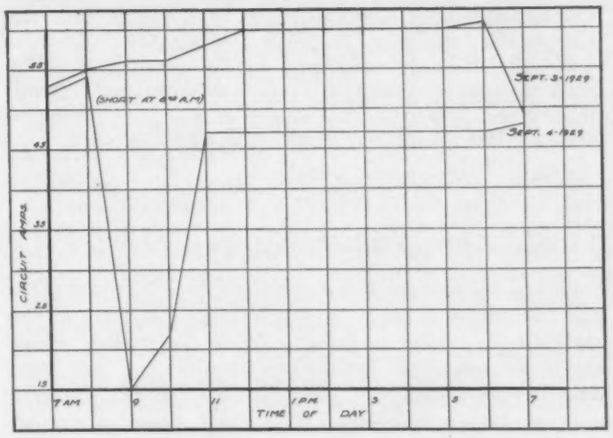

Fig. 4. Short on 11-kv. line, agricultural load.

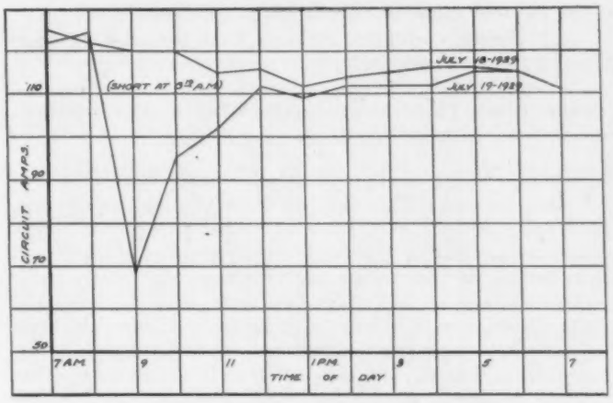

Fig. 5. Short on 11-kv. line, agricultural load.

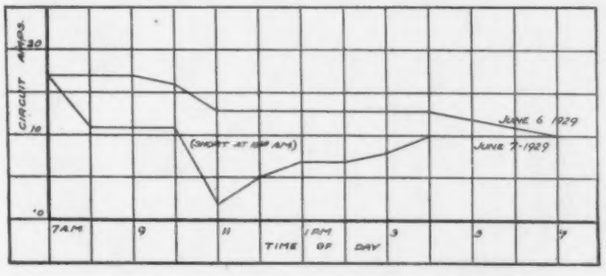

Fig. 6. Short on 11-kv. line, agricultural load.

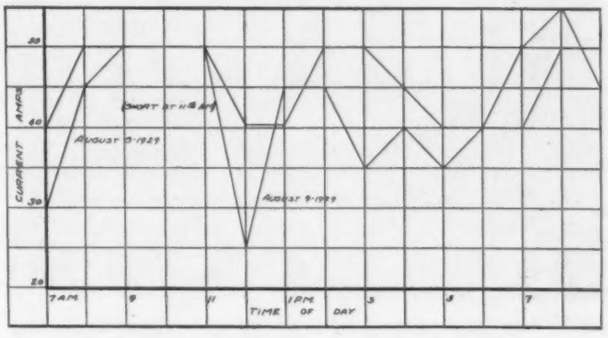

Fig 7. Short on 16-kv. line, industrial load.

per 100 circuit miles equalled that of 1923. In studying the records for 1926, we find that this was due to an exceptionally large number of interruptions caused by heavy wind and lightning storms. The curve in Fig. 2 shows the trend of trouble per 100 circuit miles of line. The number of cases of trouble per 100 circuit miles of transmission line have been reduced from 24 in 1923 to 6 in 1928.

Under the classification of trouble, we find that the unknown causes have decreased from 37.6 per cent of the total in 1923 to 27.8 per cent in 1928, which gives an average for six years of 32.5 per cent. Curves in Fig. 3 show the trend of the total unknown causes of trouble. In 1923, 10 per cent were on the transmission lines and 90 per cent on the distribution lines; in 1928, 2 per cent were on the transmission lines and 98 per cent on distribution lines. The unknown causes of trouble on the transmission lines decreased from 10 per cent of the total in 1923 to 2 per cent in 1928, whereas the unknown causes of trouble on the distribution system increased from 90 per cent of the total in 1923 to 98 per cent of the total in 1928.

It is rather surprising what a large number of unusual and unexpected occurrences will cause interruptions on distribution and transmission lines. Obviously, if we do not know the cause of the interruption, it is very difficult to guard against its reoccurrence and it may be of interest to list the cause of interruptions for one year, showing the per cent of the total due to each cause. Following is a list prepared from information submitted to the subcommittee. This covers the period from Jan. 1, 1929, to Dec. 31, 1929, and includes 11,000-volt lines and above.

CAUSES OF INTERRUPTION

Causes	Per Cent
1. Trouble on foreign companies' lines	12.11
2. Unknown	28.67
3. Birds shorted lines	5.73
4. Lightning	3.01
5. Trees in the line	5.23
6. Insulator failure	2.79
7. Consumers' transformer failed	4.44
8. Sleet and snow	0.28
9. Skyline sagged into conductor	0.21
10. Kite in lines	0.71
11. Splice failure	0.78
12. Accidental tripouts	2.43
13. Poles blown over	0.43
14. Consumers' apparatus failure	0.43
15. Wire slipped in dead end shoe	0.07
16. Oil well fire	0.07
17. Guy wires shorted line	0.07
18. Insufficient clearance consumer's transformer position	0.07
19. Air hammer jarred switch out	0.07
20. Derrick in the line—booms, etc.	1.07
21. Turkey flew into line	0.14
22. Mistakes in switching	1.43
23. Station oil switch bushing failure	0.07
24. Tree bark blown into line	0.43
25. Auto hit pole	2.22
26. Insulators broken	0.52
27. Board fell into station bus	0.07
28. Wire thrown across line	1.57
29. Wire carried into line by bird	0.14
30. Blasting under line	0.52
31. Line shorted with hot tools	0.52
32. Signal wire thrown into line by train	0.07
33. Wire shot down with rifle	0.52
34. Insulators broken by rifle	0.28
35. High winds	6.59
36. Wind loosened hot tap	0.07
37. Consumer's oil switch failure	1.57
38. Wires blown down	0.21
39. Cattle rubbing structures	0.64
40. Line gang shorted line	0.64
41. Current transformer failure station	0.52
42. Lines paralleled out of phase	0.07
43. Portable oil switch failure	0.07
44. Wire broke	0.57
45. Tin blown into line	0.28
46. Poles blown around in the hole	0.07
47. Line hardware failure	0.36

Causes of Interruption (Continued)

Causes	Per Cent
48. Underground cable failure	0.14
49. Primary fuse block failure	0.36
50. Lightning arrester failure	0.57
51. Improper relay setting	0.21
52. Man grounded line with designating sign	0.07
53. Wires blown together	0.07
54. Radio aerials shorted line	0.07
55. Insulator pin came unscrewed	0.07
56. Man shaking guy shorted line	0.14
57. Cat shorted lines, etc.	0.28
58. Station oil switch failure	0.52
59. Telephone wire shorted line	0.07
60. Pole top switch failure	0.52
61. Insulator pin broken off	0.28
62. Grounded line energized	0.21
53. Station transformer failed	0.28
64. Dredger undermined pole	0.07
65. Dirty insulators and heavy fog	0.86
66. Grounded detector troubles	0.21
67. Hot disconnect opened	0.14
68. Grass fire burned poles down	0.64
69. Station transformer bushing cracked	0.21
70. Guy wire broke, wires swung together	0.07
71. Fuse blew on potential transformers	0.07
72. Arc from primaries shorted 66 kv.	0.07
73. Steam spraying over pole top switch	0.07
74. Hay blown into line	0.07
75. Potential transformer failed	0.14
76. Derrick builders pulled wires together	0.28
77. Voltage regulator burned out	0.07
78. Improper relay wiring	0.07
79. Overload on bus tie switch	0.07
80. Tap failed due to corrosion	0.07
81. Wire pulled off of insulators	0.21
82. Brush fire burned pole down	0.21
83. Lines of different voltage blown together	0.14
84. Aeroplane shorted line	0.07
85. Low tension switch failed to relay	0.07
86. Grounding transformer failed	0.07
87. Line sagged into trees	0.07
88. Current transformer failed	0.21
89. Earthquake broke wire	0.07
90. Brush fires shorted line	0.43
91. Trees cut into line	0.78
92. Oil tank exploded	0.07
93. Bushing lug failed	0.07
94. Trip coils burned out on relay	0.07
95. Tie wire broke	0.07
96. Truck pushed pipe into line	0.07
97. Condenser switch failed	0.07
98. Fuseholder shorted	0.14
99. Pothead failure	0.14
100. Rag fell across insulator	0.07
101. Crossarm broken	0.07
102. Generator failure (electrical)	0.14
103. Hallowe'en pranks	0.21
104. Building fire	0.14
105. Man contacted line	0.07
106. Weeds blown into line	0.14
107. House moved under line	0.07
Total	100.00

We have endeavored also to make some study of the loss in amp.-hr. due to circuit interruptions. A number of 11 and 16-kv. circuits were studied where momentary interruptions have occurred to try to determine how long a period elapses before the load comes back on the circuit after such an interruption. We find in the agricultural districts that considerable time elapses before the load returns to normal. On the circuits feeding industrial business, the time is very short; in other words, the load is picked up in most cases in less than one hour's time. We were not able to get very accurate readings, as the circuit ammeters are only ready once each hour. In plotting the curves we have taken the readings of the day previous to the day on which the interruption occurred and used this as the normal load, then plotting the following day when the interruption occurred to show the drop in load and the length of time required to regain this business. It was hoped that some figure could be developed to show the loss in revenue due to circuit interruptions, as this figure would help to determine how much money could economically be spent in avoiding interruptions. Sufficient information has not been obtained to draw any definite conclusions along this line. We know, however, that the public relations suffer very materially due to interruptions, particularly on heavy industrial loads such as oil well drilling, oil refineries, foundries, etc., where considerable damage to consumers' equipment may result if the load is dropped.

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*Pole Line Structures and Devices**

This subcommittee has devoted its time to wood poles and has chosen to limit its report almost entirely to the description of tests on poles and pole treatments, which are being conducted by various agencies, so that they may be recorded in one place for their present interest and for future reference. The items reported are as follows:

1. *Cedar poles treated with arsenical solutions.*
2. *Deflection of poles under load.*
3. *Development of checks after treatment.*
4. *Percentage of poles infested with termites on operating system.*

Cedar Poles Treated With Arsenical Solutions—Full Length, Open Tank Treatment

SOLUTIONS of sodium arsenite, arsenic trioxide and a combination of these two, known as the regular solution, have been used for wood preservation purposes by the Anaconda Copper Mining Company since February, 1926. Small installations of pole stubs and railway ties treated with sodium arsenite and arsenous acid were made in December, 1925. From January, 1927, until June, 1929, 500 cubic feet of pole stubs and mine timber were treated daily by the Bethel process at the company's Rocker treating plant. This solution contained arsenic trioxide and caustic soda in the ratio of six of the former to one of the latter, having a

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* Report of subcommittee on pole line structures and devices, overhead systems committee, Engineering Section. Harold Michener, chairman. E. R. Banks, J. E. Crilly, R. E. Cunningham, C. A. P. Duffie, F. J. Gleiss, G. H. Hagar, E. A. Hart, J. F. Hodges, B. C. Holst, C. E. Ingalls, C. B. Judson, C. L. Lawrie, G. A. MacDonald, J. B. Naugle, G. E. Nott, A. J. Pahl, E. Y. Porter, J. C. Porter, D. D. Smalley, J. O. Tobey, C. E. Young.

Fig. 1. 40-ft. cedar pole under deflection test showing method of holding butt section and applying load at top.

concentration of 5 to 6 per cent arsenic trioxide. In addition, approximately 1,500,000 b.ft. of sawn timber and planking were treated in a small open tank plant at one of the mines in Butte using this same solution.

Since June, 1929, the Rocker plant has been using a neutral solution containing a ratio of arsenic trioxide to caustic soda of six to one-tenth.

During October, November and December rather large scale co-operative tests in the full length open tank treatment of Western red cedar poles with arsenical solutions were carried out at the Alhambra treating plant of the Southern California Edison Company. A total of 356 8-in. top 40-ft. poles were treated with two solutions, 180 with the regular solution and 176 with the neutral solution.

The regular solution was first made in a concentrated form and then diluted until it contained approximately 5 per cent by weight of arsenic trioxide and 0.8 per cent caustic soda. The neutral solution was obtained by the addition of sulphuric acid to the regular solution until the caustic soda was reduced from 0.8 per cent to approximately 0.05 per cent.

After thorough agitation in the storage tank, the solution was transferred by gravity to the treating tank containing sixteen poles in sufficient quantity to cover the highest point of these poles to a depth of at least 6 in. so as to allow for evaporation and absorption and still have the poles covered at the end of the treating period. The treating tank was then covered and the solution in it heated to approximately 212 deg. F. and the temperature held there for from two to four hours, after which the covers were removed and the treating tank contents allowed to cool for about fifteen hours. The solution was then pumped from the treating tank, where it was thoroughly agitated, its quantity and temperature measured and samples taken, all to help determine the amount of arsenic that had been left in that charge of poles.

The poles were all numbered consecutively and each fifth pole was designated as a test pole. Borings at specified locations were taken from these test poles as soon as possible after their removal from the treating tank. While the penetrated portion of the wood was wet, the depth of penetration could be determined very accurately. The borings were dried

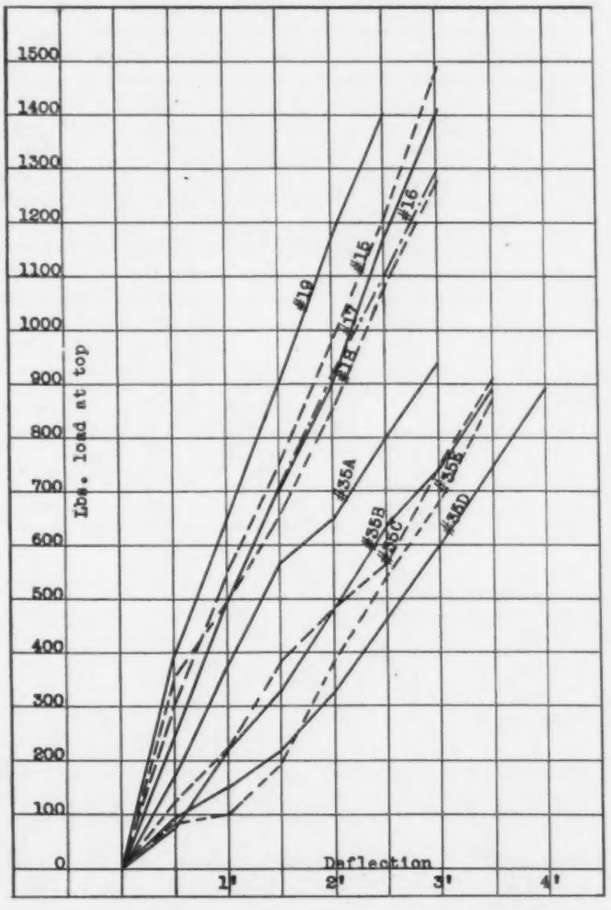

Fig. 2. Deflection tests, 35-ft. poles, August, 1929.

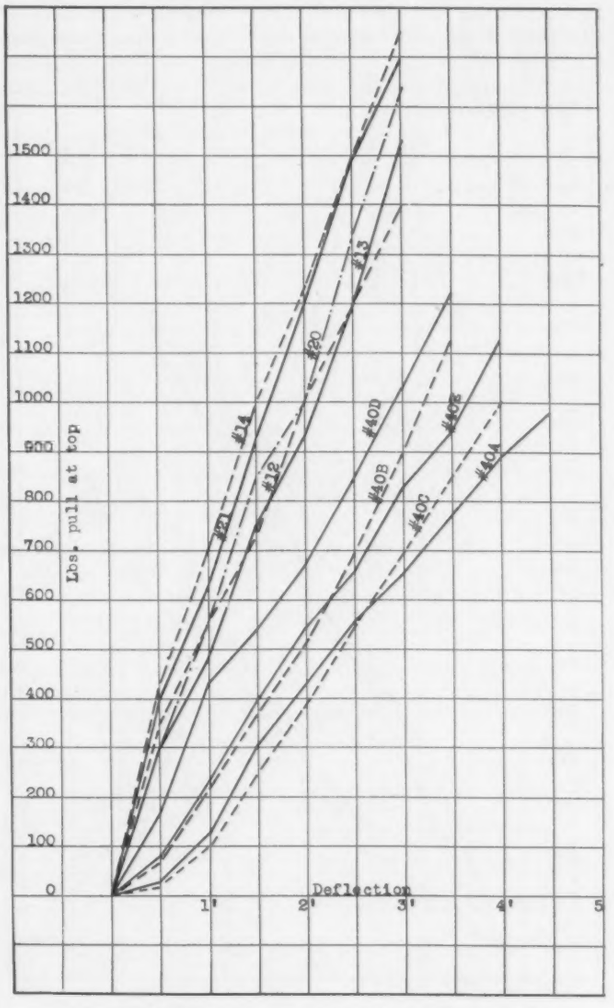

Fig. 3. Deflection tests, 40-ft. poles, August, 1929.

Douglas Fir			Western Red Cedar		
Pole Number	Top Diameter Inches	Ground Line Diameter Inches	Pole Number	Top Diameter Inches	Ground Line Diameter Inches
15	9¼	10¾	35-A	7⅝	11
16	8⅝	9⅞	35-B	7¼	9⅜
17	8¼	10½	35-C	7⅝	10½
18	8	10⅝	35-D	7⅛	9⅝
19	8⅛	10⅝	35-E	7⅛	10⅜

Douglas Fir			Western Red Cedar		
Pole Number	Top Diameter Inches	Ground Line Diameter Inches	Pole Number	Top Diameter Inches	Ground Line Diameter Inches
12	8¼	11¾	40-A	8	10⅝
13	8¾	12¼	40-B	8	13
14	8¾	12⅝	40-C	8⅝	11⅝
20	8½	11¾	40-D	8⅝	13⅛
21	9¼	12	40-E	8½	12

and analyses made to determine the amount of arsenic contained by them. From this the amount of arsenic absorbed (in lb.) per cu.ft. of penetrated sapwood, per cu.ft. of total sapwood and per cu.ft. of total wood in the poles were computed. The averages for these quantities for the 22 runs through the treating tanks are as follows:

Per cent sapwood penetrated	81.5
Pounds As_2O_3 absorbed per cu.ft. of penetrated sapwood	1.92
Pounds As_2O_3 absorbed per cu.ft. of total sapwood	1.57
Pounds As_2O_3 absorbed per cu.ft. of total wood in poles	0.42

These poles are being set in various districts on the system to get all possible variation in the amount of rainfall to which they will be subjected. Every few years new borings will be taken from the test poles to determine the amount of arsenic still remaining in the wood.

During June, July and August, 1929, the Southern Sierras Power Company applied arsenic wood preserver in the paste form to the butts of 290 Western red cedar poles in the line of its Yuma property.

These poles had been set in 1918 without treatment. At the time of the treatment the sapwood was practically gone but the heart wood was sound, except for termite runways, in nearly all of the poles. In these lines there were, in addition to the 290 poles treated with the arsenic wood preserver, eighteen new poles or poles having creosoted butts, four poles which were removed at time of treatment or marked for immediate removal on account of decay or termites, and six poles which were in wet alkali soil and were not treated with the paste. The eighteen new and creosoted poles had been set to replace an equal numbr of the original poles that had failed. This gives an idea of how well the untreated poles were lasting. Termites or termite workings were found in 122 out of the 290 poles treated.

On the poles that were treated with the arsenic wood preserver the decayed wood was shaved off and the paste applied from the ground line to depths varying from 3 to 4 ft. Costs kept on the latter part of this job show an average of $2.56 per pole including everything except overhead costs.

Under date of Feb. 27 and 28, 1930, twenty of the above poles were critically examined by excavation around the poles and chipping off the outside wood wherever indications of termite workings were found. One or two poles were excavated to a considerable depth below the application of the preservative paste in order to determine, if possible, if any termites might exist near the bottom of the pole. The soil

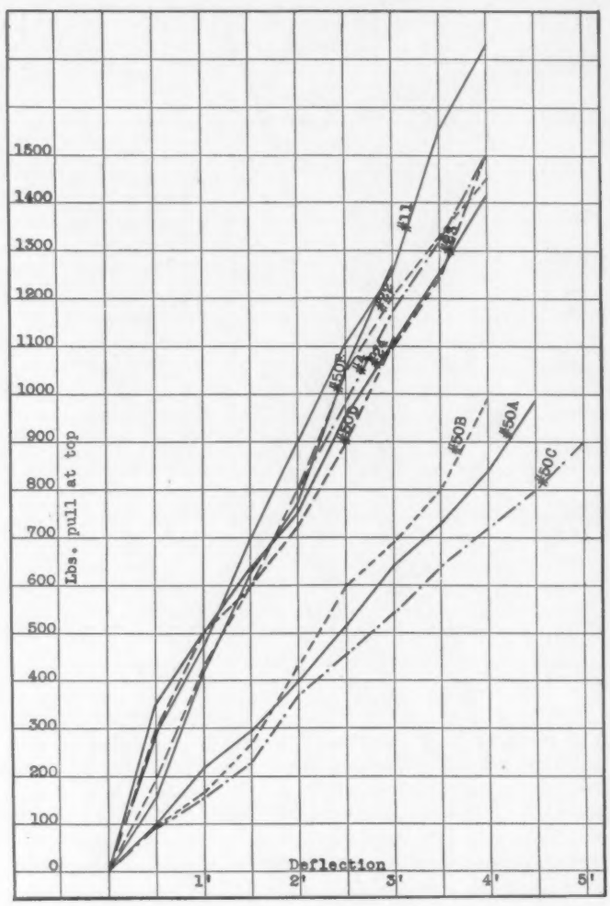

Fig. 4. Deflection tests, 50-ft. poles, August, 1929.

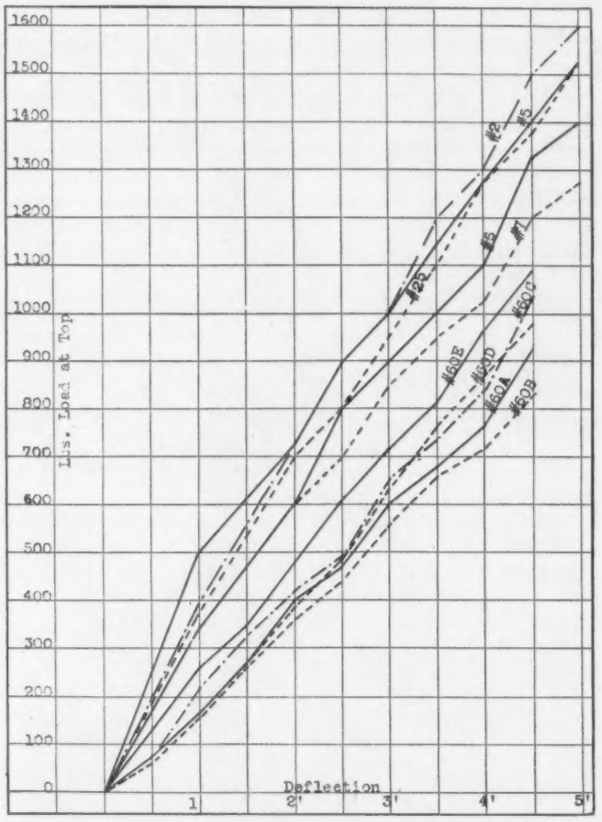

Fig. 5. Deflection tests, 60-ft. poles, August, 1929.

Douglas Fir			Western Red Cedar		
Pole Number	Top Diameter Inches	Ground Line Diameter Inches	Pole Number	Top Diameter Inches	Ground Line Diameter Inches
4	9 1/4	13	50-A	8 3/4	14 1/4
11	9 1/2	13 1/4	50-B	8 3/4	13 3/4
22	9 1/4	13 1/2	50-C	8 1/2	12
23	9 1/2	12 7/8	50-D	9 1/4	16 7/8
24	8 3/4	12 3/4	50-E	9 1/4	15 1/4

Douglas Fir			Western Red Cedar		
Pole Number	Top Diameter Inches	Ground Line Diameter Inches	Pole Number	Top Diameter Inches	Ground Line Diameter Inches
2	8	13 1/2	60-A	9	14 5/8
5	8 1/2	13 1/2	60-B	9	14 5/8
6	9 1/8	13 1/2	60-C	10 1/4	14 3/4
7	9	12 7/8	60-D	9 1/4	14 3/4
25	9	13 1/4	60-E	10	14 3/4

in practically all cases was moist and in some cases quite wet at varying depths below the surface and in all cases the wood under the paste appeared to be slightly stained a brownish color. No chemical tests have been made, however, to show whether or not this is a definite indication of absorption of the arsenic compounds. However, borings at three points, i.e., ground line, 15 in. below and 15 to 18 in. above ground were made with a view to having test made of same to determine content of arsenic. Live termites were found in all of these poles at the time the preservative was applied and naturally workings and chambers made by termites were found at the time of the recent inspection. Live termites, however, were found in only one pole. This pole had the most extensive workings and chambers of any of the poles examined, some of these chambers extending to a height of about 12 ft. above the ground, which is the highest point at which any workings have been found on poles in the Yuma district. This particular pole was completely girdled by termite chambers and about a dozen individuals were found in one pocket about 2 ft. above the ground. These were a dry wood form. The remains of dead termites were found in three of the poles.

Deflection of Poles Under Load—Comparative Tests, 25 Cedar and 25 Fir Poles

These tests were made by the fir pole producers for the purpose of obtaining experimental data to confirm calculated results and to be more convincing to those who are inclined to discount calculated results. The test set-up was as shown in Fig. 1. The below-ground section of the pole was held rigidly, while the top was deflected by a pull applied through a dynamometer, *the deflection being measured at the top.* At no time were the poles stressed to their elastic limit.

Five cedar poles and five fir poles of each of the following lengths were tested: 35, 40, 50, 60 and 70 ft. The load-deflection curves for these poles are shown in Figs. 2 to 6, inclusive. The top diameter, ground line diameter and length is shown for each pole. A few typical poles may be compared as follows:

Cedar pole No. 35E, 7⅛ x 10⅞ in. x 35 ft., was deflected 3 ft. by a pull of 680 lb., while fir pole No. 18, 8 x 10⅝ in. x 35 ft. was deflected 3 ft. by a pull of 1,275 lb.

Cedar pole No. 40E, 8½ x 12 in. x 40 ft., was deflected 3 ft. by a pull of 830 lb., while fir pole No. 20, 8½ x 11¾ in. x 40 ft. was deflected 3 ft. by a pull of 1,630 lb.

Cedar pole No. 50D, 9¼ x 16 ⅞ in. x 50 ft., was deflected 3 ft. by a pull of 1,100 lb., while fir pole No. 23, 9½ x 12⅞ in. x 50 ft., and No. 24, 8¾ x 12¾ in. x 50 ft., were each deflected 3 ft. by a pull of 1,100 lb.

The five 60-ft. cedar poles ranged in measurements from 9 x 14⅝-in. to 10 x 14⅝-in. and were deflected 4-ft. by pulls ranging from 720 lb. to 970 lb. with an average of 830 lb., while the five 60-ft. fir poles ranging from 8 to 9⅛-in. top diameter and from 12 to 13½-in. ground diameter were deflected four feet by pulls ranging from 1,030 lb. to 1,300 lb., with an average of 1,200 lb.

Development of Checks After Treatment—Observations on 25 Pressure Creosoted Fir Poles to Determine Changes in Checks After Treatment

The 25 fir poles used in the flexibility test were also used for test poles to determine whether checks which exist immediately after treatment increase or diminish in size as the poles age. In this lot there were five poles of each of the following lengths: 35, 40, 50, 60 and 70 ft. These poles were treated on July 12, 1929, to meet the tentative specification dated November, 1929. The moisture content of the outside 2-in. zone averaged for the 25 poles, was 18.84 per cent before treatment. After treatment the moisture content of the outer 2-in. zone was 13.94 per cent and that of the untreated heartwood was 24.90 per cent. The average creosote content in the penetrated area, determined by the extraction method specified, was 0.794 grams per boring. This is slightly in excess of the 0.75 grams per boring, which is approximately equal to eight lb. of creasote per cu.ft. of wood.

Within the first week after treatment the checks in each pole were measured and recorded by width and location in each quadrant on five different circumstances,—one foot from the butt, at the ground line, ten and twenty feet from the butt and two inches below the top gain.

On July 24, 1929, the poles were shipped by boat from the Pacific Creosoting Company's plant near Seattle, where they were treated, to the J. H. Baxter Company yard at Long Beach where the flexibility tests were made on Aug. 8. They stayed at the Baxter yard until Oct. 25 when they were taken to the Alhambra pole yard of the Southern California Edison Company and spread on the tops of some high piles of poles. On Dec. 11 to 17, 1929, the checks were again measured. This was five months after the poles were treated and practically that length of time in Southern California during an unusually dry summer and fall. In all that period only 0.32-in. of rain had fallen and there had been practically no fog until the last two weeks.

The checks had changed very little. Of the 886 originally recorded 300 were smaller and 120 were larger on the second measurement but most all of these differences were not greater than 1/16-in., some were ⅛-in. and only a very few of the increases as great as ¼-in.

The poles are now being installed in five scattered locations on the Southern California Edison Company system and the checks will be measured and recorded from time to

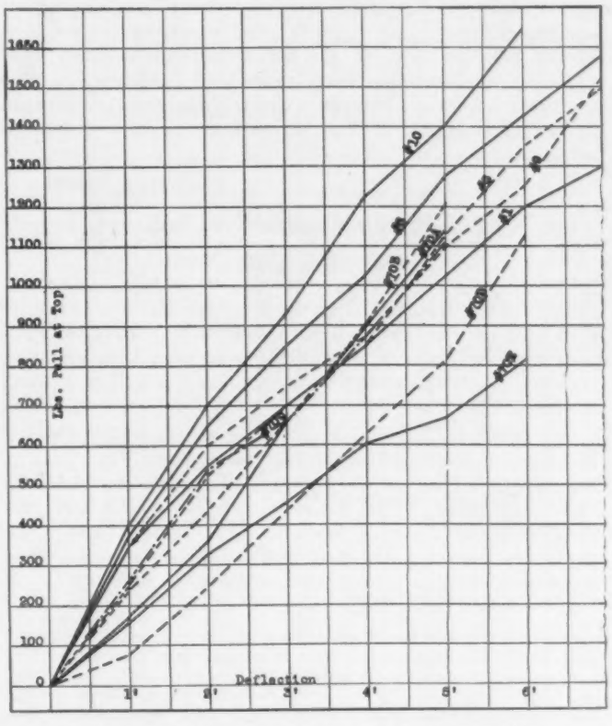

Fig. 6. Deflection tests, 70-ft. poles, August, 1929.

Douglas Fir			Western Red Cedar		
Pole Number	Top Diameter Inches	Ground Line Diameter Inches	Pole Number	Top Diameter Inches	Ground Line Diameter Inches
1	9¾	13¼	70-A	10¼	18½
3	8¾	14½	70-B	9¾	17½
8	8⅞	14½	70-C	10¾	19¼
9	9⅞	14	70-D	9½	16½
10	9⅞	14⅜	70-E	8¾	13¾

time. In this way a fairly accurate picture should be developed of the changes that take place in the checks of these poles over a long period of time.

Percentage of Poles Infested With Termites on Operating System

The Department of Water and Power, City of Los Angeles, has tabulated the poles removed from service due to all causes from Jan. 1, 1928, to Dec. 1, 1929, practically two years. All the poles set had been butt treated with creosote and the termites found were the dry wood type. These tabulations show the number of poles set each year, beginning with 1916, the number of those set each year which have been removed each month since Jan. 1, 1928, and the number of those set each year and removed each month which were infested at the time of removal.

This information has been summarized in an attempt to determine the percentage of poles set in the various years which are now infested with termites. Of course the curve of percent of poles infested with termites plotted against the years in which the poles were set is not a smooth curve, but still it is quite significant. Smoothed out a little it would start at about 95 per cent for poles set in 1916 and drop along a straight line to 15 per cent for poles set in 1925 and then flatten out somewhat for those set since that time.

Lumped in another way, 81.3 per cent of the poles set in the years 1916 to 1919 inclusive (a total of 18,300 poles), are infested with termites, and 66.7 per cent of the poles set in the years 1916 to 1923 inclusive (a total of 40,700 poles), are infested with termites. These two statements are based on the poles removed which constitute 5.5 per cent of the poles set in each case and hence seem a fairly good basis for the conclusion that the remaining 94.5 per cent of the poles are infested in approximately the same proportion. In no case were these poles removed on account of termite infestation.

Round Redwood Poles Treated With Anaconda Wood Preserver

The Pacific Gas and Electric Company has set two lines of round redwood poles butt-treated with Anaconda wood preservative. These poles were cut from second growth trees standing near where they were set. They were not allowed to season before setting.

One of these lines is located along the highway entering the state redwood park in the Big Basin, Santa Cruz County. It is about 2.7 miles in length and was completed Dec. 26, 1929. The fifteen 40-ft. poles set to a depth of 5½-ft., the 46 35-ft. poles set to a depth of 5 ft., and the five 30-ft. guy stubs set to a depth of 5 ft., were all treated, when set, with Anaconda wood preserver paste, as follows:

From one to two lb. of paste were plastered on the butt of the pole, an 18-in. collar ¼-in. thick was plastered around the pole with its lower edge 12 in. from the butt, and a 24-in. collar was plastered around the pole with its upper edge just below the ground line. Approximately 15 lb. of preservative were used per pole. The poles cost, delivered to the line, $10 each for the 30 and 35-ft. poles and $12 each for the 40-ft. poles.

The other line consists of 13 poles having butts from 11 to 16 in. in diameter, set in December, 1929, along a road in Pocket Canyon running westerly from the Guerneville-Forestville Highway, Sonoma County, some distance toward Guerneville from the Mountain View School. These poles were also set green and were treated with the dust form of Anaconda wood preserver.

*Transformer Loading and Methods of Measuring Loads**

The activities of this particular subcommittee have extended over a period of about one and one-half years and this report is intended to crystallize all of the study and findings of the subcommittee during this time. The work was probably conceived because of the fact that many companies appear to be overtransformered for some classes of service as is evidenced by the extremely few failures of transformers due to overload as well as by the very low demand factor on many large groups of transformers supplying a reasonably high class suburban load.

Most companies in determining the size of transformers to be installed for a particular connected load use the "rule of thumb" method, in existance for many years. To determine whether or not that "rule of thumb" method is correct, both economically and from the standpoint of service is the principal effort of this subcommittee. The results attained toward this end speak for themselves. They are not at all intended to be conclusive since they are the opinion of only a few individuals but they at least offer a basis for additional research. It is true that the problem might well be handled solely by mathematics but the difficulties brought about by many assumptions hard to bring into accord with actual facts, justified a study in the field under actual operating conditions. Such a field study, without the ideal conditions often existing in the laboratory, generally introduces erratic results which are not always easy to interpret, but, in spite of this fact, this method seemed the best to pursue.

TWO principal factors are involved in the study of transformer loads, the heating of the transformer due to load and the regulation of the transformer due to that load. Heating of the transformer is a comparatively simple matter to compute, knowing the characteristics of the transformer and making certain assumptions as to the magnitude and periodicity of the load. These assumptions will be found to introduce the errors in such a method. The regulation, however, is a somewhat different matter, even although the actual transformer and service regulation may be known. The human part of the equation introduces the unknown variables. Economics is a very essential part of the study, as is true with most subjects under consideration by this organization, and has to do with the relative costs of the different sized transformers and services.

Transformer loading as a subject covers an enormous field, and it seemed desirable to limit the activities of this subcommittee to one small subdivision of that subject and to endeavor to cover it in as complete a manner as possible in the time allowed. Accordingly the work has been confined entirely to the study of the loading of the smaller distribution transformers and particularly those supplying service to lights combined with electric ranges and water-heaters, together with a small amount of air heating, but not including service to residences entirely heated electrically.

Methods of measuring load on transformers include many different types of equipment and instruments, many of which have been used in connection with the studies carried on by this subcommittee. The actual load is measured by means of various types of recording ammeters, using strip charts,

* Report of subcommittee on transformer loading, overhead systems committee, Engineering Section. H. H. Buell, chairman. W. P. Champion, A. S. Glasgow, R. V. Hall, C. C. Potts, A. C. Putnam, G. A. Riley, W. C. Smith, A. E. Strong.

circular charts, and charts with double scales for recording both sides of a three-wire transformer simultaneously. The ammeters are connected to standard current transformers and to portable split-core transformers with either one or several current ranges. Recent designs have greatly reduced the weight of these portable transformers by cutting down the secondary current. Transformer temperature is measured by means of recording thermometers using circular charts, the bulb being placed in the oil and proper allowance being made for hot spot temperature. Several different devices are also available which are calibrated to read transformer load on the basis of oil temperature, allowing for the ambient temperature, while other devices are designed to indicate dangerous oil temperatures and, therefore, dangerous loads, by means of a flag or marker. Voltages are measured by means of portable recording voltmeters of as many types as there are recording ammeters. In addition, there are an equal number of indicating instruments of all types. It hardly seems necessary to elaborate on this detail. There are very few, if any, new developments in this equipment with which most engineers are not familiar.

Heating Under Field Conditions

The first part of the study involved the heating of transformers under actual load conditions in the field. A large number of representative, installations were selected at random over a certain area made up of relatively prosperous suburban properties and consisting of ranges and water heaters with lights. A few small air heaters were also included in these connections. Equipment was assembled, indicating the actual

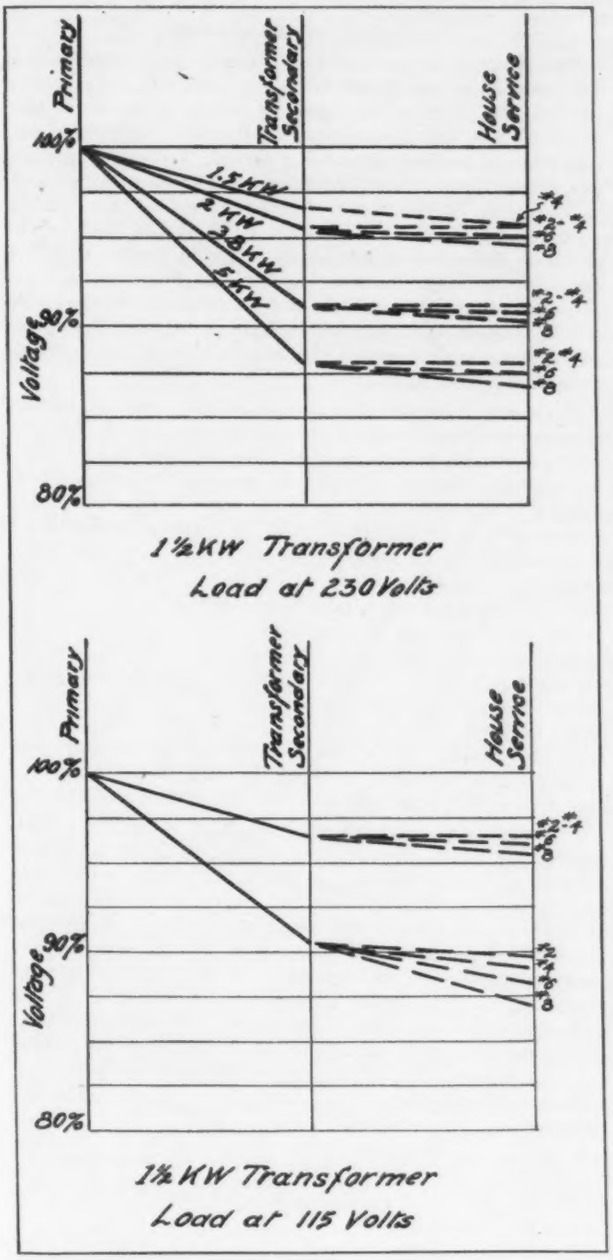

Fig. 1. 1½-kw. transformer loaded at 115 volts and 230 volts respectively.

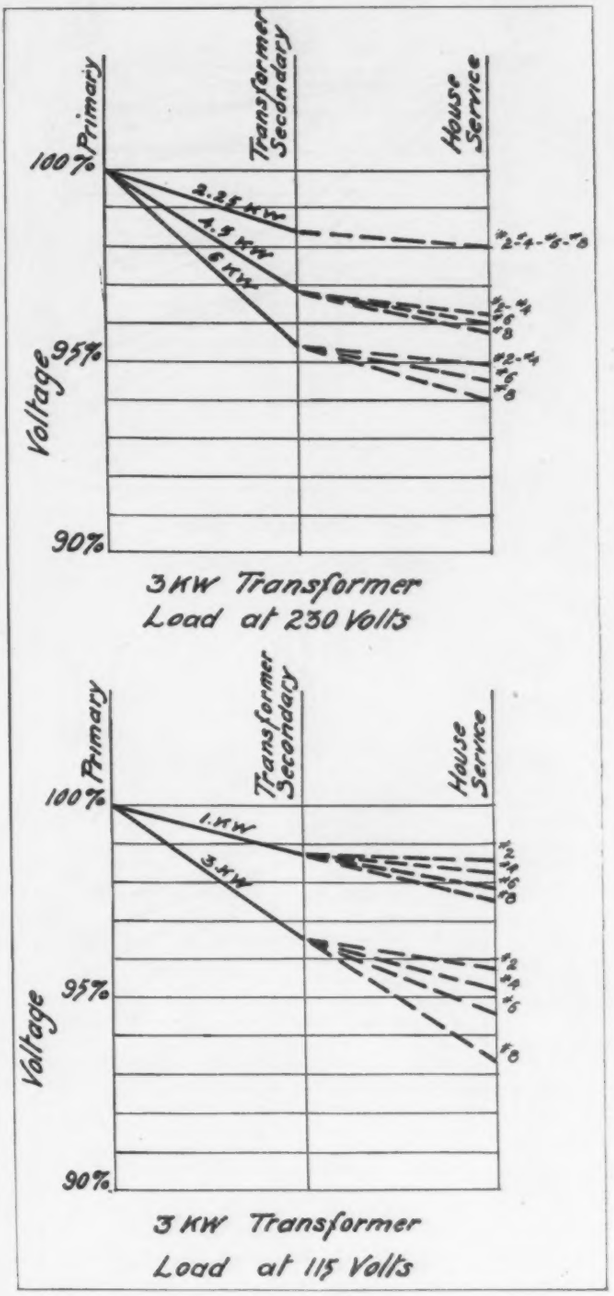

Fig. 2. 3-kw. transformer loaded at 115 volts and 230 volts respectively.

load supplied, by means of a recording ammeter connected to a three-wire current transformer. The actual oil temperature was recorded on a circular chart. The maximum percentage of full load, as determined by the oil temperature, was indicated by another instrument. A mass of data was secured which was carefully digested and, although even this was not enough to permit definite conclusions to be drawn, at least one pertinent fact was at once apparent. The transformers which were studied had been installed by the "rule of thumb" method as to size. Every transformer was found to be far larger than was at all necessary considered on the basis of heating only, and even transformers of half the customary size did not reach a temperature of more than 110 deg. F. under actual field conditions. As an extreme case, several 1½-kw. transformers were connected to installations of range, water-heater and lights and none of them reached a temperature of more than 110 deg. F. in the oil. The devices, indicating percent of full load on the basis of oil temperatures, showed practically no movement of the pointer. This shows clearly the reason why such devices ofter appear to be out of order when installed in transformers. We have a very erroneous idea of the demand factor on many classes of service, especially over a period of a number of hours. A perusal of the recording ammeter charts on such installations will indicate a very small period of time during which the major equipment is operating. There are, of course, exceptions to such a statement but the very small number of transformer burn-outs proves that the exceptions are rare indeed.

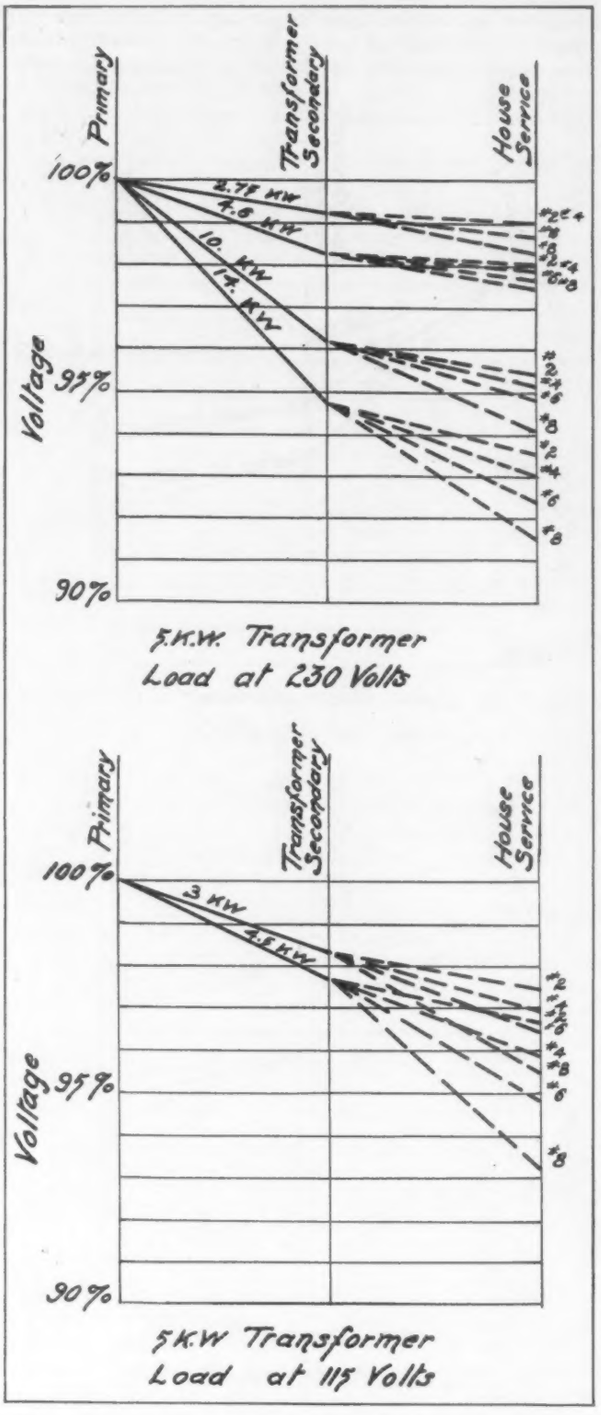

Fig. 3. 5-kw. transformer loaded at 115 volts and 230 volts respectively.

Regulation of Transformers

The study of the regulation of transformers under actual field conditions was found to be very difficult. As a matter of fact, the effect of regulation is largely a matter of personal opinion based somewhat on the past experience and education of the individual being served. Voltage drop, insofar as the class of service under consideration is involved, is evidenced in two ways: by the failure of the heating equipment to function as rapidly as it should, and by the effect on the candle power of the lamps in operation on the same service with the other equipment. The former effect is purely mechanical and is not particularly objectionable over fairly wide ranges of voltage variation. The latter effect, however, introduces the human element and necessitates careful attention.

It is a well known fact that a sudden drop in voltage of even small magnitude is at once apparent to an observer, or even to one who is merely using an incandescent lamp for reading purposes, whereas the gradual lowering of voltage to that same, or to a much lower value, will make no impression. The periodicity of the drops in voltage have a great deal to do with the effect produced. A continual rapid fluctuation in voltage of even small magnitude, such as is caused by some types of refrigerators, for instance, is very objectionable, whereas very much larger fluctuations occurring relatively infrequently will not result in criticism of service. It is interesting to note that whereas the illumination from an electric lamp drops off very rapidly with small decreases in voltage below the normal voltage of the lamp, nevertheless the illumination is still reasonably good at these low voltages, provided, as said before, that the full drop occurs gradually and not instantaneously.

In an effort to establish some standard on which to base conclusions as to permissible fluctuations in voltage, and, therefore, in candlepower, a number of tests were made and the impressions produced on several individuals noted. It must be understood that it is impossible to supply any service without a certain amount of voltage drop as the load is applied. It is a question as to the permissible magnitude of the variations giving due consideration to the economics of the problem. The effort is to determine what effect relatively large fluctuations will have on the eye. These results are merely the expression of opinion of one individual and others undoubtedly will not at all agree as to the values given.

Voltage Drop Below Normal Per Cent	Approximate Candle Power Per Cent of Normal	Relative Visual Impression
2.6	92	Excellent
4.3	87	Not objectionable
6.0	80	Severe
7.8	75	Very Severe

Because of the difficulties experienced in measuring transformer drop under actual field conditions, it was decided to set up an experimental installation and determine the transformer regulation for several of the smaller distribution transformers under various load conditions. In addition, since transformer regulation is not the only factor which determines what class of service is received by the consumer, the voltage drop in service wires of four different sizes was measured for each load and each size of transformer. It is, of course, perfectly possible to secure from the manufacturer, curves showing the characteristics of all of the distribution transformers and also to compute the resistance and inductions of each service and thus determine mathematically the total voltage drop, but the experimental measurements seemed to be perfectly easy to make and not to entail any material expense. Many engineers, at least those who have not given the matter any particular study, have long had a rather vague or misguided idea of the relative voltage drop in the transformer and in the service and the results of these tests may, therefore, prove of interest.

The following is a summary of the tests made:

Transformers tested—1½, 3, 5 & 7½-kv., 2,300-115/230 volts.
Services—Nos. 8, 6, 4, and 2, each 95 ft. long.
Load—Approximately the load which might be applied when a water heater or range oven is turned on—together with larger values merely to indicate the relative drop in the transformer and service. Before the advent of the load balancing switches, 3 kw. at 115 volts, represented by the top and bottom units in the oven, would be turned on instantaneously and this condition was included in the tests.

The readings taken are not intended to be exact and precision instruments were not used. The values are, however, close enough to true readings to be comparative.

The results of the tests are shown in the following figures which have been arranged in form given for convenience.

A number of very interesting facts will be apparent on studying the charts, and any one combination of transformer and service can be compared with any other combination. For instance, a 5-kw. transformer with No. 8 service will be found to compare very favorably with a 3-kw. transformer with No. 2 service, as to performance, whereas the cost of the two installations is approximately the same. In considering these values one should remember the very low demand factors of installations of this type. Probably the first impression one will receive is the relatively large voltage drop in the transformer compared with the service.

In order to improve the situation as regards transformer regulation and its effect on service, several corrective measures are indicated. It is a fact that the manufacturers have materially improved the efficiency of transformers year by year, but have not improved the regulation at all. A comparison in this respect between transformers manufactured 10 years ago and those of today will show almost exactly the same regulation. It would seem that this characteristic might well be the subject of research, especially when it is known that transformers in service, large enough to provide proper regulation, are far larger than necessary considering heating. If regulation of transformers cannot be improved practically and without increase in costs, it would appear that the time is ripe for the development of a self-compounding transformer without moving parts and without a material increase in costs. There seems to be a place also for a heating element with a high negative coefficient of resistance, apparently a fanciful suggestion but one which would be helpful. Another suggestion has to do with the visual effect of voltage drop and involves the development of lamps designed to respond to voltage changes much more slowly than do present lamps. Load balancing switches on electric ranges have gone a long way toward lowering the amount of load turned on instantaneously but the use of 5-kw. water heaters in this territory has counteracted that result to a very large extent. In these heaters the entire load is turned on at one time. The technical magazines have discussed water heating in other localities with the use of considerably smaller units, which would improve the situation materially.

No definite conclusions are offered by this subcommittee and the data secured are presented merely for the consideration of the membership of the association.

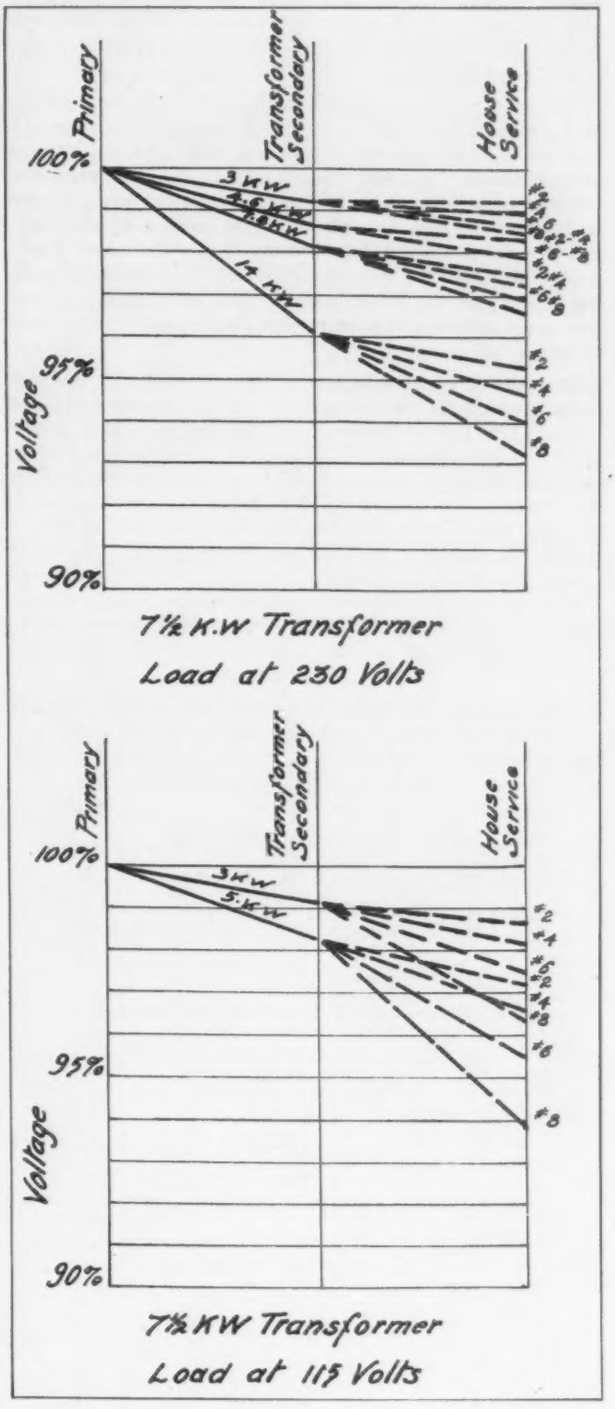

Fig. 4. 7½-kw. transformer loaded at 115 volts and 230 volts respectively.

PRIME MOVERS COMMITTEE REPORTS[2]

*Prime Movers Committee Activities**

STEAM power plant development on the Pacific Coast has advanced rapidly during the past twelve months. Unit No. 11 in the Long Beach plant of the Southern California Edison Company and the new San Francisco plant of the Great Western Power Company are both in service. Work on the first Pacific Coast 1,400-lb. installation at Station A of the Pacific Gas and Electric Company is progressing rapidly and it is planned to have the first unit ready for the fall loads. Work has also commenced on the new unit for the Button Willow plant of the San Joaquin Light and Power Corporation.

Due to the progress that is being made, the work of the prime movers committee is becoming more and more important and a large amount of valuable data is being reported and published. In order that this data may be preserved for future reference in the most available form, considerable thought has been given to the method of preparing and arranging reports for publication in "Electrical West". A special committee was organized for the purpose of making a study of the whole matter. This committee has been named the subcommittee on review and its report is included herewith.

The reports which follow have been arranged by the subcommittee on review to conform to the recommendations contained in its own report, including the changing of the names of subcommittees to correspond with the new permanent classification recommended. Due to the earlier date set this year for the submitting of final reports, the time available has been rather short for the subcommittee on review to place itself on a working basis and perform its newly created functions. We believe, however, that the improved results are already apparent in the reports published herewith and that increasing benefits may be anticipated as the recommendations set forth in this subcommittee's report are put into effect.

The subcommittees which have been active this year and a summary of the work reported on are given in the following table:

1. Review
   - Permanent Classification of Subcommittees
   - Suggestions for Writing Reports
   - Suggestions Regarding Conduct of Technical Sessions
2. Turbo-Generators and Auxiliaries
   - Turbine Room Equipment at Station A, San Francisco
3. Instruments, Automatic Control, and Plant Records
   - Automatic Combustion Control
   - Remote Control of Gas Pressure Regulators
   - Feed Water Control
4. Operating and Maintenance Practice
   - Furnaces, Oil Burners, and Fuel Oil Pumps
   - Boiler Feed Pumps and Feed Water Regulators
   - Safety Valves
   - Economizer and Superheater Tube Failures
   - Turbines and Condensers
   - Evaporators, Extraction Heaters, Drainers, etc.
5. Heat Balance, Design, and Plant Betterment
   - Ideal Steam Cycles
   - Probable Plant Efficiencies for Various Cycles
   - Representative Results from Actual Plants
   - Heat Balance Diagram of a Modern Plant
6. Water Conditioning and Power Plant Chemistry
   - Requirements for Correct Water Conditioning
   - Short Methods for Making Routine Analyses
   - Carry-over from Boilers
   - Water Conditioning Practice at Seal Beach Station

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*Report of Subcommittee on Review**

This report includes recommendations for certain changes in the method of carrying on the work of the prime movers committee with a view to establishing greater continuity from year to year, and eliminating duplication of effort and overlapping of the work of subcommittees. A definite plan of procedure is outlined, including a system of permanent classification of subcommittees, suggestions regarding the writing of reports and the conduct of technical sessions and a plan for organizing each succeeding year's work.

A SURVEY of the prime movers committee reports for the past five years has indicated that there has been considerable duplication of effort and in some cases an appreciable amount of overlapping of the work of two or more subcommittees functioning during the same year. It is also the opinion of many of the members that more consideration could profitably be given to the planning and organizing of new subcommittees. The subcommittee on review has been organized for the purpose of studying all the factors involved, no definite limitations being set on the scope of its activities.

After carefully considering the problem from every angle, this subcommittee respectfully submits the following recommendations relating to: (1) A system of permanent classification of subcommittee work; (2) Suggestions for writing reports; and (3) Suggestions regarding the conduct of technical sessions including a plan for organizing each succeeding year's work.

Permanent Classification of Sub-Committees

Briefly this plan consists in establishing a permanent classification of subjects under which all future subcommittee work may be carried on. In this way a certain degree of continuity from year to year would be automatically established and published reports of subcommittees would be enhanced in value due to their more systematic arrangement.

Subcommittees would be appointed as usual but they would make their reports under the various permanent classifications, making use of suitable subheadings which would best apply to the particular work assigned. It is possible that

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[2] H. S. Markey, Great Western Power Company, chairman. C. H. Delany, Pacific Gas and Electric Company, vice-chairman.
Allis-Chalmers Manufacturing Company: F. H. Searight.
General Electric Company: R. F. Monges, E. E. Valk.
Great Western Power Company: J. S. Moulton, C. P. Rhine.
Hawaiian Electric Company, Ltd.: L. A. Hicks.
Leeds & Northrup Company: L. E. Emerich.
Los Angeles Gas and Electric Corporation: G. H. Briggs, M. R. DeLisle, F. R. Knight, R. F. Leefeld, E. G. MacDonald, Weller Reed, H. E. Thompson, C. H. Zeise.
Moore & Company, C. C.: D. P. Vail.
Pacific Gas and Electric Company: P. E. Chapman, V. F. Estcourt, H. N. Mosher, M. E. Mulkey, W. N. Munroe, R. C. Powell, C. E. Steinbeck.
San Diego Consolidated Gas & Electric Company: E. D. Sherwin, C. W. Wiggins.
San Joaquin Light & Power Corporation: A. Y. Meudell, H. T. Shirley.
Southern California Edison Company: J. W. Andree, H. C. Bennett, Scott Jensen, L. J. Kraps, August Sattler, W. H. Short, Raymond Wilcox.
Southern Sierras Power Company: V. E. Johnson.
Westinghouse Electric & Manufacturing Company: C. H. Brunner, R. A. Hopkins.

* Report of H. S. Markey, chairman prime movers committee, Engineering Section.

* Report of subcommittee on review, prime movers committee, Engineering Section. V. F. Estcourt, chairman. J. W. Andree, N. Cohn, F. R Knight, A. Y. Meudell, E. D. Sherwin, Raymond Wilcox.

occasionally the work to be covered by a certain subcommittee would fall under two or more permanent classifications; in such cases the subcommittee in question would make its report in two or more parts each being reported under the heading of the permanent classification which applies. A situation could also occur wherein too many of the subjects selected to be reported upon would fall under the same permanent classification and thus overburden one subcommittee; this condition would be met by appointing two different subcommittees to make reports under the heading of the same permanent classification but under different subheadings. Thus, for example, subcommittee A would report under the subheading of turbine lubrication and subcommittee B would report on preparation of operating code manual, both these subjects would be reported and published under the permanent classification heading of operating and maintenance practice (see below, permanent classification No. 8).

In formulating the following permanent classification of subcommittees, the intention has been to make it embrace the entire prospective field of activity of the prime movers committee and at the same time concise enough to form a practical working instrument. It should be understood that the object is to provide a classification into which any subject that might be selected will fit. The chairman of the prime movers committee will appoint only those subcommittees which are needed to carry out the year's work and the remaining subcommittees listed under the classification will be inactive for that year. It is recommended that the classification of subcommittees be arranged as follows:

1. Review.
2. Turbo-generators and auxiliaries.
3. Condensers and auxiliaries.
4. Boilers and auxiliaries.
5. Fuel burning equipment, fuels, and furnaces.
6. Instruments, automatic control, and plant records.
7. Station piping.
8. Operating and maintenance practice.
9. Heat balance, design, and plant betterment.
10. Water conditioning and power plant chemistry.
11. Plant management.
12. Oil and gas power.

In order to suggest the scope of each classification listed above, the following outline has been prepared. It should be understood that this can be modified or added to as found necessary from time to time without affecting the general scheme:

1. *Review*—It is recommended that the chairman of this subcommittee be the vice-chairman of the prime movers committee, and further that each vice-chairman be appointed to serve for a period of three years, the first year in the capacity of chairman, the second as an ex-officio member, (assuming that he is also chairman of the prime movers committee during that year) and the third year as a regular member. It is clear that this arrangement will result in the vice-chairman, chairman, and the previous year's chairman of the prime movers committee all being members of the subcommittee on review at the same time. Two or three additional members should also be appointed from the membership at large and one at least of these should be employed by the same company as the chairman in order to be able better to assist in the large amount of routine work. In this manner a certain degree of continuity will be automatically preserved in the activities of this subcommittee from year to year.

While it may not be possible or desirable to give any legal status to the above recommendations, this year's subcommittee on review believes that the effectiveness of such an arrangement is so apparent that each incoming chairman of the prime movers committee will see fit to follow the general plan outlined when appointing members to serve on this subcommittee.

It is recommended that the subcommittee on review should perform the routine duties and other special work outlined below.

(*a*) To act in the capacity of an editorial committee for all reports submitted for publication in "Electrical West" paying particular attention to the following:

1. See that all reports are placed under the correct subject headings and in the same order as given under the permanent classification of subcommittees.
2. Collaborate with the chairman of the prime movers committee in preparing an introduction to the published prime movers committee reports as a whole.
3. Rearrange the individual tables of contents submitted with each report and combine them into a tabulated outline of subject matter to appear as part of the introduction mentioned under item (2). An idea as to what is required in this way may be had by referring to the introduction to this year's prime movers committee reports. (See also below, "Suggestions for Writing Reports", item (*b*).)

(*b*) To prepare, when considered desirable, a brief review of the general progress and trends of the entire power plant field. It is also permissible for this subcommittee to select someone outside its membership particularly qualified to write such a report.

(*c*) To assist the chairman of the prime movers committee in arranging the programs of the technical sessions, particularly in the matter of seeing that the members in general are informed in advance of subjects of special importance, so that they may come prepared for discussion.

(*d*) To review the minutes of other geographical sections and report any data that might be of interest to Pacific Coast plants. This data should be reported at the technical sessions and incorporated in the minutes of the meeting.

(*e*) To make a thorough investigation of the most desirable subjects for study during the coming year and submit recommendations in writing at the April meeting each year. This should include, when desirable, a survey of the work of past subcommittees in the light of present day development with recommendations for a review or further report in order to bring the subject up to date. These recommendations should be incorporated in the minutes of the April meeting but not in the final published report of this subcommittee appearing in "Electrical West". (See also below, Suggestions Regarding Conduct of Technical Sessions, Item (*d*).)

2. *Turbo-Generators and Auxiliaries*—To include all reports relating to the design and performance of both main and auxiliary turbines, and turbine auxiliaries such as generator air coolers, stage feedwater heaters, evaporators, turbine oil coolers, etc., as for example:

(*a*) Member companies' statements regarding design of equipment, defects, or suggestions for improvement in construction.
(*b*) Manufacturers' statements regarding the latest developments in design and performance of equipment.
(*c*) Physical data on new installations of equipment.
(*d*) Performance and test data of equipment.
(*e*) Turbine blade failures.

3. *Condensers and Auxiliaries*—To include all reports relating to the design and performance of condensers and condenser auxiliaries such as circulating pumps, air pumps, condensate pumps, cooling towers for condensers, etc., as for example:

(*a*) (*b*), (*c*), and (*d*) of Classification No. 2.
(*e*) Corrosion of condenser tubes.

4. *Boilers and Auxiliaries*—To include all reports relating to the design and performance of boilers, superheaters, economizers, reheaters, air preheaters, forced and induced draft fans, feedwater pumps, etc., as for example:

(*a*), (*b*), (*c*), and (*d*) of Classification No. 2.
(*e*) Boiler tube failures.

5. *Fuel Burning Equipment, Fuels, and Furnaces*—To include all reports relating to the design and performance of liquid and gaseous fuel burners, furnaces including water

cooled and air cooled walls, refractories, fuel oil pumps, etc., as for example:

(*a*), (*b*), (*c*), and (*d*) of Classification No. 2.

6. *Instruments, Automatic Control, and Plant Records*—To include all reports relating to the design and performance of instruments, automatic control equipment such as automatic combustion control systems, feedwater regulators, temperature and pressure regulators, etc., also handling of charts, the methods of reporting results of operation, and so forth, as for example:

(*a*), (*b*), (*c*), and (*d*) of Classification No. 2.
(*e*) Plant records, handling of charts, etc.
(*f*) Application of various instruments for various purposes.
(*g*) Relative merits of various types of instruments for performing the same function.

7. *Station Piping*—To include all reports relating to the design, manufacture, and performance of piping, valves including boiler safety valves, fittings and flanges, and metallurgical problems relating to the manufacture and use of this equipment, as for example:

(*a*), (*b*), (*c*), and (*d*) of Classification No. 2.
(*e*) Manufacturing and fabrication problems in connection with materials of construction.

8. *Operating and Maintenance Practice*—To include all reports relating to the method of operating and the frequency cost, and kind of maintenance of various equipment including the development of standards of performing this work to the best advantage, lubrication problems, and methods of inspecting and checking equipment, as for example:

(*a*) Frequency, cost, and kind of maintenance necessary on various equipment under various load conditions.
(*b*) Standard methods of cleaning, repairing, or overhauling equipment at minimum cost.
(*c*) Standard methods of starting up, operating, and shutting down equipment.
(*d*) Study of reliability factors of different equipment under various load conditions, including data on necessary outages for repairs, etc.
(*e*) Maintenance material, such as packing, etc.
(*f*) Lubrication of turbines and auxiliaries.
(*g*) Routine inspections.

9. *Heat Balance, Design, and Plant Betterment*—To include all reports relating to the design and heat balance of power plants, and the study of all subjects relating to plant betterment from an operating standpoint, as for example:

(*a*) Data on the design and heat balance of various plants.
(*b*) Influence of load on plant economy for various hook-ups.
(*c*) Design and operation of standby plants for best economy.
(*d*) Standards of operation for best economy, including the economics of shut-downs for cleaning or routine overhauling.
(*e*) Methods of routine and special testing of equipment.
(*f*) Economics of routine and special testing of equipment, including studies of the return on labor investment for such work.

10. *Water Conditioning and Power Plant Chemistry*—To include all reports relating to the chemical treatment and other methods of conditioning boiler feedwater and condensing water including the design and operation of boiler blow-down systems, steam purifiers, etc., also any study primarily of a chemical nature relating to any phase of power plant design or operation, as for example:

(*a*), (*b*), (*c*), and (*d*) of Classification No. 2.
(*e*) Chemical treatment of boiler water and condensing water.
(*f*) Control of boiler blow-down and its relation to feedwater conditioning.
(*g*) Prevention of carry-over from boilers.
(*h*) Condenser leakage problems as related to feedwater conditioning.
(*i*) Evaporator performance as related to feedwater conditioning.
(*j*) Miscellaneous studies and data relating to power plant chemistry.

11. *Plant Management*—To include all reports relating to plant management including the organization, functions, education, and safety of plant personnel, as for example:

(*a*) Statistics on organization at various plants, including the function and duties of different groups within the organization with data on relative wage scales for various classes of labor. Note: The matter of wages may be treated on a relative basis without using the actual figures.
(*b*) Study of the effect of plant design on plant organization and relative wage scales for various classes of labor with reasons for same.
(*c*) Methods of educating and training personnel.
(*d*) Premium systems, etc., for employees.
(*e*) Safety First organization and methods.
(*f*) First Aid organization and methods.

12. *Oil and Gas Power*—To include all reports relating to the design, performance, and operation of oil and gas engines with particular reference to their relation to steam power plants on the Pacific Coast, as for example:

(*a*), (*b*), (*c*), and (*d*) of Classification No. 2.
(*e*) Relative cost of Diesel and steam power plant installations on the Pacific Coast.
(*f*) Relative cost of operating Diesel and steam power plants on the Pacific Coast.
(*g*) Combined Diesel and steam power plants for handling peak loads.
(*h*) Items (*a*) to (*g*) for any other type of oil or gas engine-generator that might become a competitor of the steam turbine-generator.

Note: The above classification of subcommittees was approved by the prime movers committee at the Los Angeles meeting held on Jan. 17, 1930, with the exception of "Oil and Gas Power" which was not included in the list at that time. This subject was suggested by some of the members at a later date and it was felt that it might be well to include it in the classification in view of the outside competition along this line, although it is somewhat problematical whether the prime movers committee would ever feel called upon to investigate this field.

Suggestions for Writing Reports

(*a*) Manuscripts submitted for publication should be typewritten with double spacing and conform in every way with the rules published by Electrical West under the heading of "Manuscript Preparation." Copies of the latter may be obtained either through the chairman of the prime movers committee or directly from Electrical West.

(*b*) All subcommittee reports submitted for publication in Electrical West should include a table of contents in order to furnish a basis for the preparation of the tabulated outline of subject matter to be compiled by the subcommittee on review. An idea as to what is required in this way may be had by referring to the tabulation appearing as part of the introduction to this year's prime mover committee reports.

(*c*) To aid in maintaining uniformity from year to year, subcommittee reports should be arranged for publication in the same serial order as given in the permanent classification of subcommittees.

(*d*) Under the present plan of procedure all Pacific Coast Electrical Association reports must be in the hands of the editors of Electrical West by March 15 each year. In view of this, all reports for publication should be in the hands of the subcommittee on review not later than February 15 in order to allow this subcommittee time to carry out its editorial duties in connection with these reports.

(*e*) The length of reports can sometimes be considerably reduced by avoiding the quotation of lengthy statements from different sources. It is usually more desirable to combine and condense the various statements into one comprehensive report.

(*f*) Detailed tabulations of replies to questionnaires should be avoided when possible, or in any case such tabulations should not be included without an attempt to draw some conclusion as to the trend indicated by the replies.

(*g*) It is believed that much benefit will be derived if subcommittees will more frequently undertake to submit recommendations as to the best practice to meet certain specific conditions, in addition to presenting statistics as to what the practice is in individual plants.

SUGGESTIONS REGARDING CONDUCT OF TECHNICAL SESSIONS

(*a*) The subcommittee on review believes that the success of the three technical sessions held during the year depends largely upon establishing an approximate balance between the formal and informal parts of the program.

In the past there have been frequent occasions when a written report was read which was of such a nature that a great deal of it could not be properly digested by listening to a reading of it. That part of a report containing references to formulas, diagrams, etc., is not suitable for reading and it is recommended that subcommittee chairmen be specifically instructed to omit the reading of anything that, due to its involved nature, cannot readily be grasped by an audience.

(*b*) In line with the thoughts expressed in item (*a*), it is believed that in most cases it is more desirable for subcommittee chairmen to present either an informal resume of the report or to read a prepared abstract. In this way a saving in time will be effected and the presentation at the meeting will be more understandable than if there were included a number of involved details only suitable for publication in written form.

It is also felt that a definite limit should be set on the time consumed for the reading of prepared reports. While it might be desirable for the prime movers committee chairman to vary this limit as the occasion demands, it is felt that perhaps twenty minutes should be the maximum time allowed. Subcommittee chairmen should be notified in advance as to how much time will be allotted to them for the reading of their reports.

By limiting the formal reading of reports in this way it is felt that there will be more time available for informal discussion and that it will be easier to draw forth the discussion if the reports are abstracted and presented in an informal manner as suggested.

It is the opinion of this committee that every possible means should be used to encourage informal discussion of subjects of a controversial nature.

(*c*) Advance copies of all reports to be read at a coming meeting should be sent to the prime movers committee chairman at least one week previous to the meeting so that he may be enabled to plan the program more effectively.

(*d*) Due to the fact that all reports must be in the hands of the subcommittee on review by February 15 each year, the April meeting, usually held in Fresno, is very suitable for discussing the program for the coming year and the subcommittee on review should submit a report (as outlined under item "E" of the duties of this subcommittee—see above) of recommendations as to the most timely subjects for study during the coming year. This should be thoroughly discussed at the April meeting and an agreement reached on the program to be undertaken.

(*e*) It is further recommended that at the April meeting the new subcommittees should be organized to the extent of appointing the chairman so that the work can be started without delay. These appointments would be subject to the approval of the incoming chairman of the prime movers committee who is not appointed until the June convention; but inasmuch as the man appointed is usually the vice-chairman of the previous year, this plan should work out very smoothly and efficiently. The several months of inactivity that have usually existed in the past between April and September would also be avoided.

*Turbo-Generators and Auxiliaries**

This subcommittee has confined its activities this year to a brief description of the new turbine room equipment at the Pacific Gas and Electric Company's Station A, San Francisco, including a heat balance diagram and a drawing showing the general arrangement of the two turbo-generators, condensers, and jet pumps.

TURBINE ROOM EQUIPMENT AT STATION A, SAN FRANCISCO—PACIFIC GAS AND ELECTRIC COMPANY

THE installation under construction consists of two 50,000-kw. vertical compound turbo-generating sets. The steam conditions are 1,250 lb. gage, 750 deg. F. at the throttle, and each set consists of a 12,000-kw., 1,250-lb., 3,600-r.p.m. high pressure unit mounted on the generator of the 38,000-kw., 1,800-r.p.m. low pressure unit. Each set will have a maximum capacity of 62,500 kw. at unity power factor.

The steam is reheated between high and low pressure turbines, first, in a live steam reheater, and, second, in a convection reheater incorporated in the boiler unit. There is a common 1,250-lb. steam header, but each set has its own live steam and convection reheaters. There are no cross connections on the reheat stem lines. All of the steam for each low pressure turbine is reheated in a single boiler unit. The live steam reheaters take 1,350 lb. saturated steam directly from the drums, are mounted above, and the condensate drains by gravity back to the drums, the operation being entirely self-regulating.

For normal operation the set is governed only by the high pressure turbine governor, but the high pressure turbine may be cut out and the low pressure turbine operated by cutting in a governor which controls a throttle valve supplied from the 1,250-lb. line. This throttle valve in combination with an orifice reduces the pressure to that required by the turbine. At maximum output of 52,000 kw. on the low pressure turbine, the pressure is reduced from 1,250 lb. to approximately 500 lb.

When the low pressure turbine is operated alone, the steam is desuperheated by the No. 1 heater before passing to the convection reheater in order to avoid excessive steam temperature to the low pressure turbine. The live steam reheater is cut out.

The condensers are each 34,000 sq.ft., two pass, and will maintain a vacuum of 28.75 in. mercury when supplied with 36,000 g.p.m. of salt water at 60 deg. F.

The water boxes are divided and the tubes are expanded into both tube sheets, the tubes being bowed to take care of expansion. The condensate pumps are driven by 60-hp. slip-ring motors and the speed is automatically controlled by floats connected to the condenser hotwells.

The general arrangement of the equipment is shown by the heat balance diagram given in Fig. 2.

The primary boiler feed pumps take water from the deaerating heaters, and pump through the high pressure heaters at 600-lb. pressure to the secondary pumps which boost the pressure to 1,625 lb.

The primary pumps are driven by 600-hp., 1,750-r.p.m., 2,300-volt, squirrel cage motors, which will be started by throwing across the line. The secondary pumps will be driven each by two turbines, each rated at 1,250 hp., one turbine taking steam from the exhaust of the high pressure turbine, and exhausting to the No. 2 heater, and the other taking steam from a 325-lb. line and exhausting to the main

* Report of subcommittee on turbo-generators and auxiliaries, prime movers committee, Engineering Section. R. C. Powell, chairman. C. H. Brunner, Boyd Henderson, R. A. Hopkins, R. F. Monges, F. H. Searight, E. E. Valk.

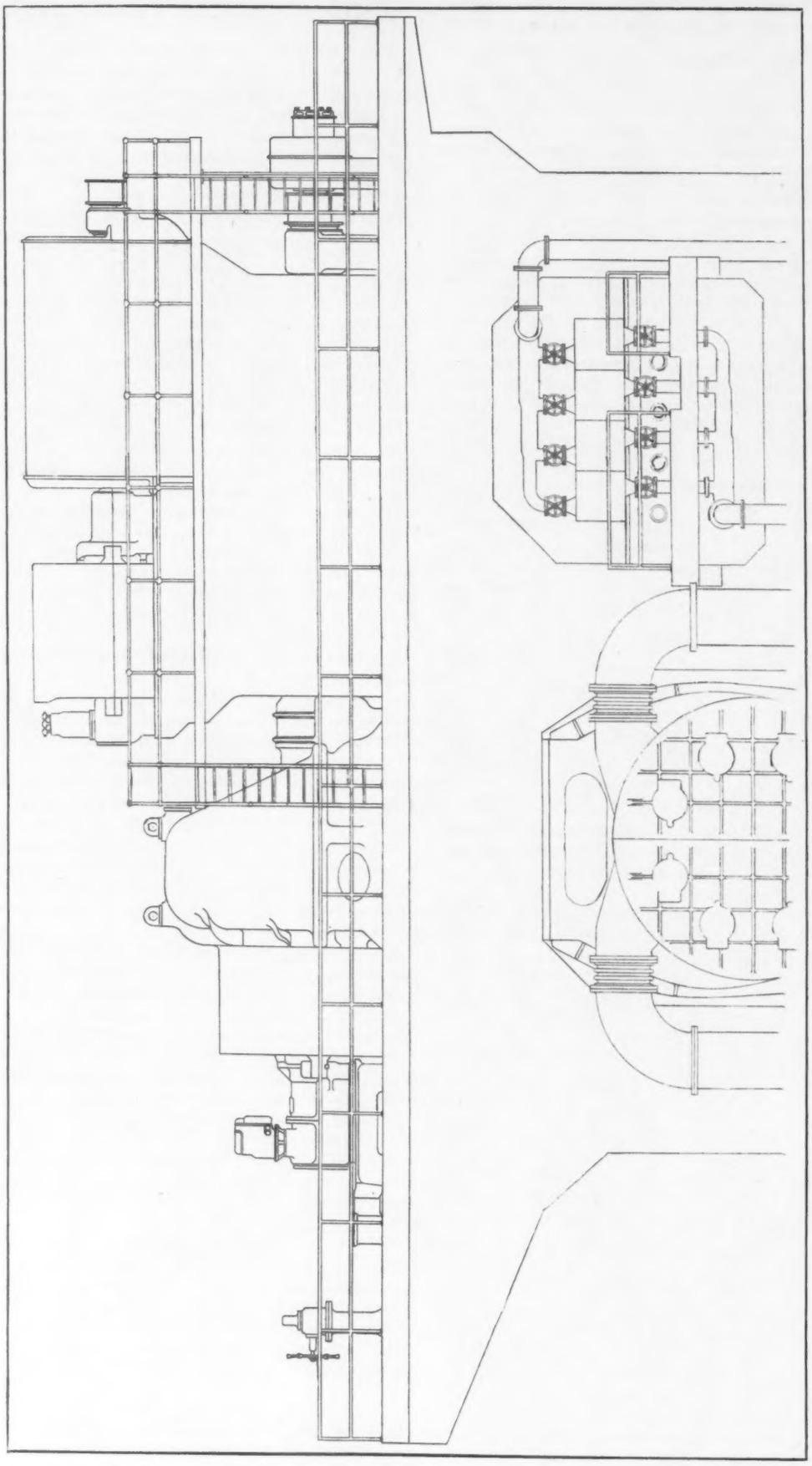

Fig. 1. General arrangement of 50,000-kw. vertical compound turbo-generator set, Station A, San Francisco, Pacific Gas and Electric Company.

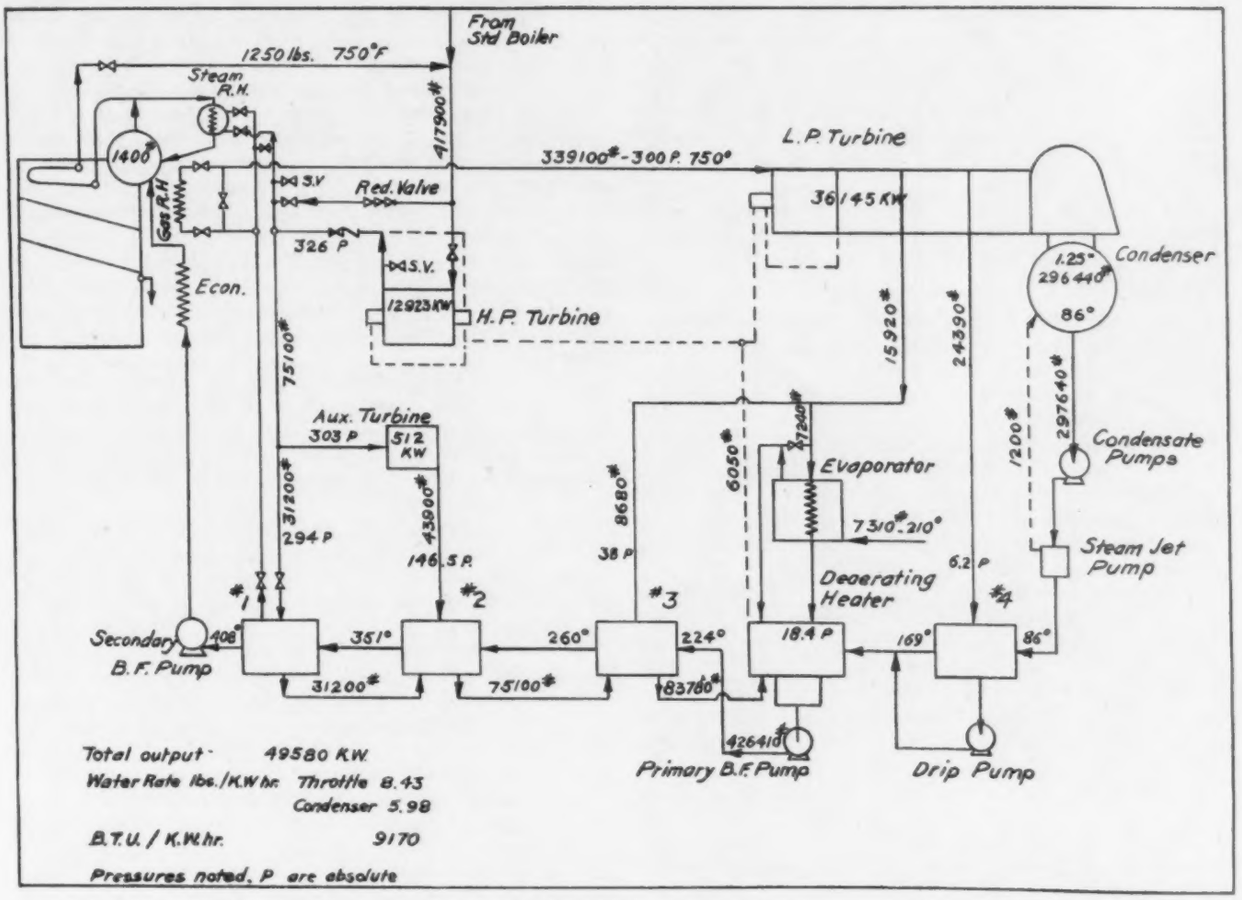

Fig. 2. Heat balance diagram for 50,000-kw. turbine, Station A, San Francisco, Pacific Gas and Electric Company.

condenser. The 325-lb. line is supplied from two 900-hp., 350-lb. boilers and reducing valves from the 1,250-lb. lines. The spare secondary pump will be driven by a single condensing turbine.

Each turbine will be equipped with a recording speed indicator, bearing, generator, steam and exhaust casing thermometers, and the usual pressure and vacuum gages, control signal system, etc.

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*Instruments, Automatic Control and Plant Records**

This report contains descriptive data and operating experiences with certain types of automatic control equipment in use on the Pacific Coast, as follows: (1) Automatic combustion control equipment, (2) A system of remote control of gas pressure regulators and (3) Feedwater regulation.

Automatic Combustion Control

Essential Requirements—

AN AUTOMATIC combustion control system may utilize compressed air, oil pressure or electricity as the operating medium, the master control regulating the dampers, forced and induced draft fans and fuel feed by pilot valves or switches so as to insure proper combustion conditions at all loads. The system must be designed to adjust fuel and air so that they will take care of characteristics of equipment at various settings, and correct for changes in quality and condition of fuel, atmospheric conditions and condition of the fire and boiler setting. It must maintain steam pressure under all load conditions.

Safety features are an important part of any control equipment. They should include limits which will prevent overtravel of rheostats, drum controllers, dampers, valves or other mechanisms being controlled. They should also protect against runaway conditions in case of failure of the power supply. It should be impossible, for instance, to change the air supply to the minimum or the fuel supply to the maximum without a corresponding change in the other controlled items. Other desirable safety features include interlocks between the fuel and air supply to prevent further increase in fuel after the maximum air delivery position has been reached, or further decrease in air supply after the minimum fuel delivery has been attained. Provision should be made for manual control for use during starting periods and at such times as the control may be out of service for repairs.

It has been the attempt of this subcommittee to get as wide an expression of experience and opinion regarding automatic control from operating companies as possible. However, some of the systems in use on the Pacific Coast have not been in operation long enough to acquaint the operators with all their characteristics. For example, the automatic features of the equipment for the two 3,500-boiler horsepower cross-

* Report of subcommittee on instruments, automatic control and plant records, prime movers committee, Engineering Section. R. A. Wallingford, chairman. H. C. Bennett, M. R. DeLisle, M. E. Mulkey, J. M. Renfrew, H. T. Shirley.

drum boilers at Station C, Oakland, have not yet been tried out due to various causes not related to the equipment itself. A description of this apparatus will therefore be reserved until such time as it has been thoroughly tried out and data regarding its performance is available. The Great Western Power Company has recently installed at its San Francisco plant a very complete system of automatic control designed especially for stand-by service, but this company is not yet ready to make a report.

The equipment in use at the Long Beach plant of the Southern California Edison Company has been in operation for a considerable length of time and data of interest is reported herewith.

Installation at Long Beach Plant No. 3, Unit No. 10—

During 1928 and 1929 a system of automatic combustion control was installed on three 3,416-boiler horsepower cross-drum boilers for unit No. 10 of the Long Beach steam plant, Southern California Edison Company.

These boilers are equipped with combined gas and oil burners, the fuel controls working on the gas and oil valves simultaneously. The movement of the control serves to open the gas valve and close the return oil valve, or to close the gas valve and open the oil return, thereby accomplishing the same end regardless of fuel used.

Fuel is controlled through chronometer valves selected for their satisfactory opening and flow characteristics.

Forced and induced draft fans are driven by a.c. brush shifting motors. Speed control is accomplished by brush movement transmitted from control drive by chain and sprockets. That for the two forced draft fans is operated as a unit through connecting shafting. The induced draft fan, of course, has its individual control.

This automatic control consists of mechanisms or drives controlling the fuel and air to each boiler. Drives are powered by fractional horsepower a.c. motors operating continuously in one direction. Backward and forward or "more" and "less" is produced by solenoid operated clutches. All solenoids use 125-volt d.c.

Drives are installed for fuel valves, forced draft dampers and brush shift, and induced draft dampers and brush shift. Travel limits are provided in forced and induced draft fan drives to prevent over-travel. Interlocks are arranged so that the fans cannot be energized for starting with control in any other than starting position. Quick return clutches which operate separate high-speed gears return the fans to starting position when the breakers to fan motors are opened. Interlocks are arranged between fan and fuel drives so that when maximum position of induced draft fan is reached no further increase of fuel can take place. The forced draft fans are interlocked with induced draft fans so that forced draft fan cannot be started unless the induced draft fan is running. Forced draft fans are interlocked with cold air doors so that the forced draft fan cannot be operated with the cold air doors open. Fuel shut-off valves are interlocked with induced draft fans so that failure of fan voltage will cause the fuel to be shut off after a definite time, as set by hesitating type under-voltage relay. P. Q. type relays are installed in series with the under-voltage relay so that in case of restoration of voltage before time set, fuel valve will open again.

Fuel drives are provided with limits to prevent over-travel. Also an electrical travel limit to prevent closing fuel drive below the minimum safe operating fuel pressure. Interlocks also are provided so that when the safe minimum operating position is reached, no further reduction in forced or induced draft can take place.

Boiler can be operated by manual or automatic control through a drum switch located in the center of the boiler room. Automatic control by steam pressure is by contacts or impulses from the master contactor. Manual control is by push button.

Readjustments on fans for air flow steam flow ratio and furnace draft pressure are made by small contactors located in the individual boiler meters. These contactors are controlled by a set of interrupters. Readjustment contacts are made approximately ten times per minute for furnace draft, and six times per minute for the air flow-steam flow relation. The furnace draft contactor operates on the forced draft fan, whereas the steam flow-air flow relation contactor works on the induced draft fan.

Since installation some changes seemed necessary. These included the following: The speed of drives was increased 100 per cent. Chain sprockets were re-designed to give more action on the brush shifts and fuel valves. Drive springs were changed to Bendix type. Differential relays to boilers were changed to heavy duty type. The cams on the interruptors were changed to a very sharp top to prevent burning contact tips and also to get shorter readjustment impulses. Gas pressure compensator bells were re-designed for a higher

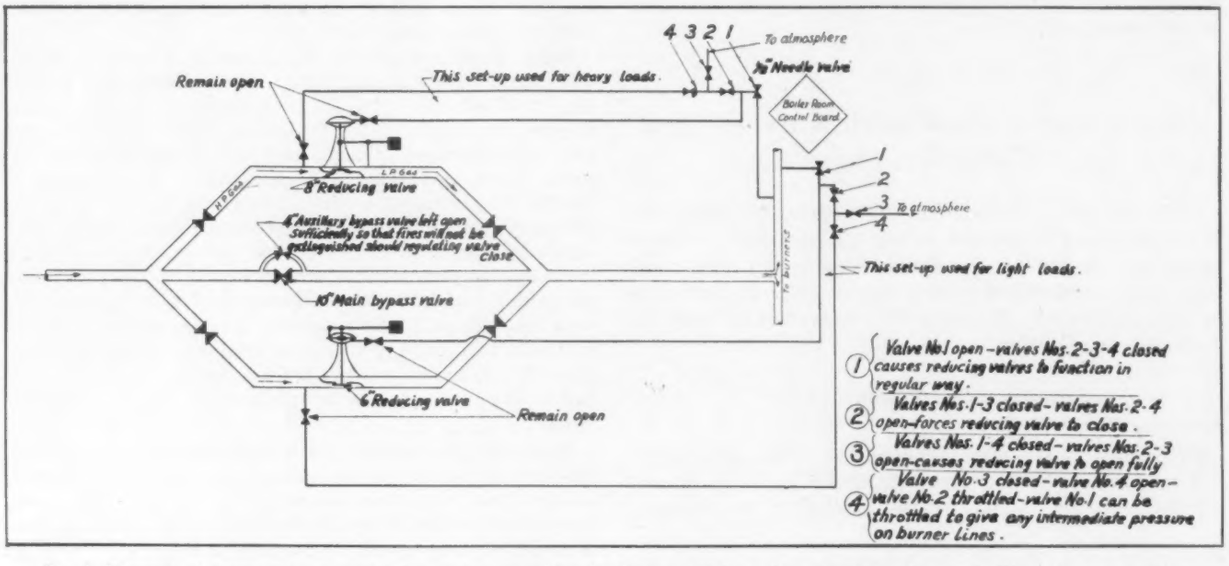
4 3 2 1
To atmosphere
Needle valve
Remain open
This set-up used for heavy loads.
Boiler Room Control Board
8" Reducing valve
L.P. Gas
H.P. Gas
4" Auxiliary bypass valve left open sufficiently so that fires will not be extinguished should regulating valve close
To Burners
To atmosphere
This set-up used for light loads.
15" Main bypass valve
6" Reducing valve
Remain open
1 Valve No. 1 open – valves Nos. 2-3-4 closed causes reducing valves to function in regular way.
2 Valves Nos. 1-3 closed – valves Nos. 2-4 open – forces reducing valve to close.
3 Valves Nos. 1-4 closed – valves Nos. 2-3 open – causes reducing valve to open fully
4 Valve No. 3 closed – valve No. 4 open – valve No. 2 throttled – valve No. 1 can be throttled to give any intermediate pressure on burner lines.

Fig. 1. Diagram of layout of gas regulating valves at Alameda Street Station, Los Angeles Gas and Electric Corporation, showing system of remote control.

pressure due to changes in gas pressure. Drum switches were changed to auxiliary spring finger type.

When installed the control drive on the induced draft fan on one of the boilers was set and adjusted, but due to our own inexperience a small amount of over-travel was allowed with the quick return clutches, causing a see-saw action when these would operate. This caused the travel limit shaft gear pin to shear, which in turn allowed the fan brush shift to become disengaged on the starting position and to shear the keys in the damper shafting. This occurred three times before the apparent riddle was solved. Due to the loosening up of the shafting, brush shift, dampers, etc., the inertia of the drive was carrying the travel limit shaft past the neutral point, or 5.5 on the position indicator, and causing the "below" and "above" quick return clutches to fight each other. This was overcome by increasing the lap of the travel cams. Since this adjustment was made no further trouble has been experienced.

Relays as furnished gave so much trouble due to the interlocking contacts breaking that they were replaced by heavy duty type with mechanical interlocks. We have had no trouble with the latter.

Drive springs as furnished broke quite frequently and were replaced by Bendix type drive springs with no further breakage up to the present time.

Since installation, our automatic combustion control has been in service 24 hours each day except when changes were being made.

Boilers for unit No. 11 are being equipped with the same type of automatic control and will be in service in the near future. Satisfactory results have been obtained with this control in every respect.

Remote Control of Gas Pressure Regulators

At the Alameda St. station of the Los Angeles Gas and Electric Corporation an interesting system of remote control of gas pressure regulators has recently been installed. The arrangement is clearly shown in the accompanying diagram and was designed for the purpose of providing an accurate means of control for a wide range of loads.

Feed Water Control

The data which follow include a statement of the operating experiences with various types of feedwater regulators at Long Beach plant No. 3 and Station C, Oakland.

Statement by the Southern California Edison Company—

At Long Beach steam plant No. 3, pressure in excess of boiler pressure is maintained on the boiler feed pump discharge by an excess pressure regulator controlling the speed of the motor drives. As installed, this is an arrangement of combined manual and automatic control. The manual control consists of a hand operated rheostat of a small number of large steps. The automatic then is arranged to control the space between the steps of the manual control. A little trouble has been experienced due to the automatic control not having enough range to cover the space between the steps of the manual. The remedy has been to maintain a higher excess pressure at the feed pumps than formerly considered necessary, and install throttling excess pressure regulators on each of the three boilers.

For the purpose of test the three boilers were equipped with three different makes of excess pressure controls in combination with water level regulators.

The original installation on each boiler consisted of a float-operated regulator on each end, and no other excess pressure control than that mentioned in connection with the feed pumps. This was the arrangement that proved highly satisfactory on the boilers of plant No. 2. Conditions did not turn out so pleasantly, however, on the larger boilers of plant No. 3.

Trouble developed due to a tendency of the original regulator valves to jam closed when the excess pressure was accidentally or otherwise raised considerably above the normal setting. This occasional rise in feed pressure seemed to be unavoidable and it was considered imperative to install the excess pressure regulators on the individual boilers. The excess pressure at which the original water level regulator seemed most inclined to give trouble as mentioned above, was in the neighborhood of 32 lb., so the attempt was made to hold this at 20 lb., but with only partial success.

The regulator on boiler No. 49 is a balanced valve directly connected to a diaphragm control in which the excess pressure (the differential pressure across the water level regulator valve) is balanced against an adjustable spring in compression. The high pressure or excess pressure communicates with the top of the diaphragm directly through the opening for the valve stem. The valve stem does not pass through any stuffing box and its movement is practically frictionless. Considerable trouble was experienced due to the diaphragms of these valves puncturing. The cause of such trouble was more or less of a mystery for a time, but acting on information from the Los Angeles Gas and Electric Corporation, we came to the conclusion it was due to too free circulation of the hot feed water between the valve and the top side of the diaphragm. We installed a washer in the valve body leaving a hole only large enough for the valve stem to work freely, thus preventing free circulation of hot feed water and overheating the rubber diaphragm. (See also statement by Pacific Gas and Electric Company below.)

The regulators as installed on boiler No. 50 were designed for a variable excess pressure, varying directly as the square of the load on the boiler. This would, of course, mean that the same opening of the water regulator valve would maintain the same water level in the boiler, regardless of load. This should have been accomplished by establishing a balance between differential diaphragms working on the air flow through the air preheater and the controlled differential or excess of the water. In other words, the air flow was to be the guide. However, due to the large differential across the air preheater it was necessary to make the water differential end of the balance arm so long that the small diaphragm used (1.7 sq.in.) could not allow movement enough to operate the pilot valve of the regulator sufficiently. We tried making straight differential or excess pressure regulators of these by removing the air head and substituting weights. As such the regulators have given us very satisfactory service.

Their action is open to the objection that the hydraulically operated valve is slow moving and cannot catch quick pressure fluctuations until after they have reached the regulator valves and the harm, if any, has been done. We had a few instances of this sort of trouble and suffered a little damage to our water level regulating mechanism due to slamming shut. In each instance, however, the excess pressure regulator came into action immediately after and restored a normal condition, with but a few seconds' delay.

Manufacturers of the water level regulators sent us a new type of valve plunger built on a stream-line pattern which was considered to be less susceptible to trouble from excessive pressure. This was installed on one end of our boiler No. 50 in series with one of the excess pressure regulators. It was tested out by gradually raising the excess pressure to determine when, if at all, the excess pressure would seriously interfere with its actoin. Nothing happened until the excess was raised to 95 lb. At this pressure the valve suddenly slammed shut, throwing the whole feed pump pressure plus that pressure caused by the water hammer against the valve. This threw the excess pressure regulator into action. With the excess pressure valve closing, the pressure against the water level regulator was reduced, and it opened, causing the excess pressure valve to open up again, which again caused the water level regulator to slam. This

cycle of action was repeated quite rapidly, probably some eight or ten times before the excess pressure regulator could be put under control and things brought to a standstill. In the course of the violent action the float and the float arm of the water level regulator were damaged and considerable water thrown out of the float. It was necessary to jack the valve open and put the water to this boiler on hand control. The float apparently failed to fill as it should and we tried flooding the float chamber to fill it but failed in this.

When the regulator was opened there was no apparent reason found for the float, though damaged, not filling. We came to the conclusion that the condensate drip from the steam connection to the top of the float chamber was not dripping freely into the float funnel, but was running down the walls of the chamber. To remedy this we installed a bronze nozzle in the top or steam connection to center the drip and keep it clear of the chamber wall. We also removed insulating covering from the steam pipe in order to increase the condensate available. No further trouble has been experienced with this particular regulator. As other similar regulators were taken out of service for inspection or other reasons they have been equipped with the stream-line valve plungers and the drip centering nozzles, with quite satisfactory results.

The regulators on boiler No. 51, which are of the thermostatic type, were apparently installed with too large ports in the valve cylinders for smoothest action, though these have been changed once for smaller ones. The ports, being large, allowed but very small movement of the cylinders of either the excess pressure valves or the water level regulator valve. This has resulted in excessive wear at the points where cylinders and seat rings make contact. This wear was all on the down-stream sides of the valves, showing the presence of considerable sidewise thrust.

Comparison of the operation of the two types of feed water regulators has, in our experience, greatly favored the open float type in many ways. Notable among these are:

1. We have found that water levels vary with the rate of steaming, the higher ratings giving us the lower water levels and vice versa. This tendency is, in a measure, a protection against priming and we know that with high ratings there is always some danger from this. The open float type of regulator allows a greater variation of level with change of boiler load and therefore affords greater protection from priming.

2. We have also noted a less tendency toward periodical swings or hunting on the part of the open float type than with the thermostat controlled regulator. These periodical swings as recorded on water level recorders to be at approximately twelve minute periods and as extensive as 2½ in., have continued unabated for hours at a time and have at times defied all efforts to stop them. No such trouble has been experienced with the float type regulators.

Statement of the Pacific Gas and Electric Company—

At Station C, Oakland, the boiler feed pumps are driven by variable speed induction motors. The speed range is from 1,480 r.p.m. to 1,760 r.p.m., and is controlled by a speed regulating controller operating with a pressure regulator. The equipment provides for automatically regulating the speed of the slip ring induction motor in such a manner that the pressure is maintained constant within certain limits. The regulator has a step by step action obtained by means of an intermittent driving gear which operates in combination stepped-out-of-cam. A variation of pressure operates a pilot switch energizing either a fast or a slow contactor which controls the starting and stopping and direction of rotation of a pilot motor. This motor drives, through suitable reducing mechanism, a drum controller. The drum controller regulates the secondary resistance of the pump motor and controls its speed. Since putting the plant into operation, our load has been so steady that we have not used this automatic feature at all except to try it out when we first put the plant into operation.

For controlling the water level in the boiler drums we are using a feed water regulating valve in combination with an excess pressure valve. We have had no trouble with the water level regulating valve, but we have had a great deal of trouble with the diaphragms in the excess pressure valve. The diaphragm chamber of the valve has one side connected to the feed water line on the pump side of the automatic feed valve. Every time there was a sudden change in pressure in the feed line the diaphragm would rupture. The trouble was due to too much clearance around the valve stem which connects the valve to the diaphragm. We learned from the Southern California Edison Company that it had had the same trouble and had eliminated it by inserting a bronze bushing around the valve stem, greatly reducing the clearance. We have done the same thing with our valves allowing 1/32-in. clearance all around. The bushings have been in about six weeks now and we have not lost a diaphragm since making the change. The bushing is installed in the flange which connects the valve body with the diaphragm chamber.

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*Operating and Maintenance Practice**

This report contains data relative to maintenance costs and operating experiences with boilers, furnaces, turbines, condensers, and miscellaneous auxiliaries. Questionnaires were sent to member companies and the replies received have been arranged herewith into a form most suitable for future reference.

Furnaces

IN LINE with the suggestions made at the San Francisco meeting last September, this subcommittee has made an attempt to obtain, among other things, data pertaining to the comparative cost of refractory maintenance of the various types of furnace walls. It was found that this information is in most cases not readily available or that it is not very reliable because the load factor has varied over a very wide range, making the figures for the cost per boiler hour run or per boiler horsepower installed of very small value. A few figures were received, however, that may be of value. Some carefully kept costs were submitted relative to the furnace maintenance of boilers burning lampblack as fuel, but the subcommittee on review has omitted the publication of them with the idea that they are not of general interest to the member companies.

Long Beach Plant—

The segregated cost data is not complete enough to give definite and extremely accurate information, but for a general comparison the solid wall set-up in plant No. 1 over a period of two years cost an average of $0.341 per installed boiler horsepower per year.

Plant No. 2, which is a combination of air-cooled and partially protected water wall furnace, over a period of five years, cost an average of $0.219 per installed boiler horsepower for furnace maintenance per year.

Plant No. 3, which is a completely protected water wall furnace, cost, over a period of one year, $0.055 per installed boiler horsepower for furnace maintenance.

The maintenance costs of oil fuel are considerably more than gas fuel due to the difference in furnace temperatures obtained with the two fuels. Furnace temperatures, using gas for fuel, run about 2,700 degrees F. while oil will sometimes reach 3,100 degrees F.

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* Report of operating and maintenance practice subcommittee of prime movers committee, Engineering Section. H. N. Mosher, chairman. E. G. MacDonald, W. N. Munroe, W. H. Short, H. E. Thompson, D. P. Vail, C. H. Zeise.

Seal Beach Station—

Air cooled walls are used, built of a tongue and groove interlocking type of brick. The approximate maintenance cost of the furnace of our No. 5 boiler, which furnace has just been rebuilt, was $0.40 per operating hour. This expense, however, is not purely due to failure of refractories, but includes a considerable amount of repairs, due to mechanical failures of walls which were finally surmounted through changes in the supports of the setting.

We have no data available on comparative maintenance cost of gas as against oil, due to the fact that, excepting short runs, gas is burned exclusively.

Some difficulties had been experienced relative to packing and maintaining joints between sinuous tube headers and brick settings, due to the fact that the relative expansion travel of the two are in opposite directions. This condition was remedied by freeing the tile interlocking with the tube header, providing a sliding surface for it and permitting the tube header to carry the tile with itself in its travel. This may be seen in the accompanying photographs.

Alameda Street Station—

Due to the unlike conditions under which the boilers of this station and those of Seal Beach are operated, comparative maintenance costs are of no value. In this station solid furnace walls are used. Seal Beach station boilers are equipped with air cooled furnace walls with cast iron ducts. The boilers in this station are operated at a very low rating, which averages below 75 per cent and the boilers at Seal Beach are operated at ratings which will average over 200 per cent. The average furnace maintenance cost of 890-hp. Stirling boilers in this station, with solid walls, is 16 cents per operating hour.

As this station operates on natural gas over 90 per cent of the time, no data is available on the comparative cost of furnace maintenance for gas and oil.

Station A, San Francisco—

We have no actual figures giving comparative maintenance costs of refractories under the conditions mentioned, but the following information will probably be of some interest:

In 1924, two class XIII-32 Stirling boilers were installed at this plant. They were set with solid walls and equipped with mechanical burners operating on natural draft. The average life of the furnace walls was only a few weeks at loads of about 200 per cent rating and the maintenance costs were prohibitive. At a later date the furnaces were completely rebuilt with hollow air ventilated walls, and with this change the average maintenance costs were approximately the same as for the old style solid setting when using steam atomized oil burners.

In 1926, water walls of the bare tube type were installed in one of the boilers for trial purposes. This resulted in a marked reduction in furnace temperatures and prolonged the life of the brickwork somewhat at heavy loads, although as much and possibly more trouble was experienced due to spalling when operating under standby conditions.

References to Data Previously Published in P.C.E.A. Proceedings—

Furnace Maintenance With Water Walls and Air Preheaters—1927 Proceedings, pp. 249-250, 253-4; 1929 Proceedings, pp. 121 and 125.

Effect of Gas and Oil Firing on Furnace Maintenance—1928 Proceedings, pp. 262 and 277 (bottom).

Oil Burners

The Los Angeles Gas and Electric Corporation has recently made an interesting change in the design of the oil burner connections at its Seal Beach plant. In order to get away from flexible metallic tubing, with its undesirable features, including cost, the change in burner couplings shown in the accompanying photograph has been made. Copper tubing supplants the flexible. That section of the coupling to which the tubing connects, is mounted stationary to the boiler front; it had been found that after the proper location of the oil burners within the furnace once had been established, flexibility was no longer needed.

The section of the burner which carries the diffuser and burner was supplied with a handle to facilitate manipulation. The new arrangement also makes for greater speed and safety and incidentally improves the appearance of the boiler fronts.

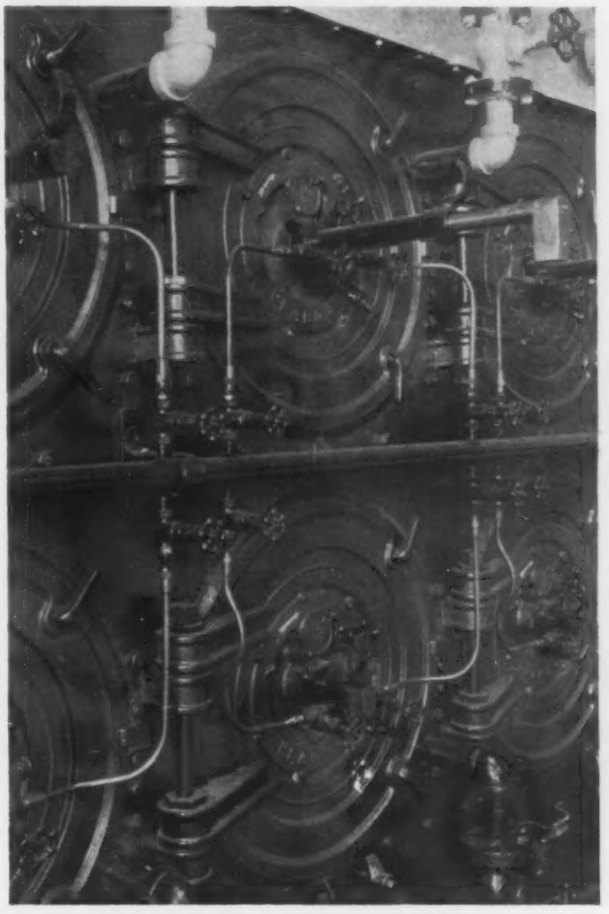

Fig. I. Combination gas and oil burners with rigid copper tubing in place of flexible, Seal Beach Station, Los Angeles Gas and Electric Corporation.

Gear Type Fuel Oil Pumps

Station C, Oakland—

Our geared fuel oil pumps are of two types. The pumps which supply the oil to the burners are the worm geared type. The return oil pumps are the herringbone geared type. Our supply oil pumps gave us a little trouble when first put into service, but with a few minor changes operated satisfactorily, and since then have given no trouble whatever. Our return oil pumps have been a mechanical failure. However, the manufacturer is making a new design which will be installed and tried out in the near future. The operating conditions on the return oil pumps is quite severe, due to the hot oil and sudden and large pressure changes on the suction and discharge ends of the pumps.

No trouble was reported by any other member company with the geared type of fuel oil pump.

Boiler Feed Pump

Seal Beach Station—

Our boiler feed pumps are designed to deliver 1,000 g.p.m. against a total head of 450 lb. per sq. in., speed 1,750 r.p.m. Originally these pumps came equipped with bronze shaft sleeves. Our packing and sleeve problems caused us considerable apprehension. We then replaced the bronze sleeves with others made of chrome nickel steel and changed from metallic to wire inserted asbestos packing.

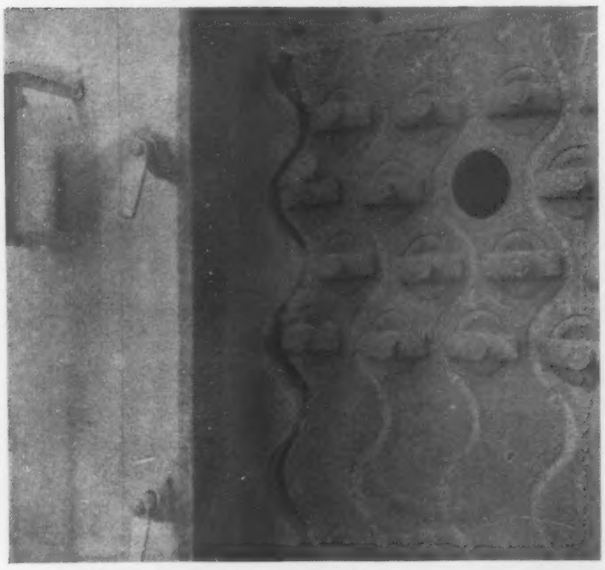

Fig. 2. Boiler No. 6 before making changes to joints between tube headers and brick setting, Seal Beach Station, Los Angeles Gas and Electric Corporation.

Over a period of 20 weeks after the change, our packing cost for these pumps had shrunk to $8.60 as against $360 for a like period previous to the change. Our total packing expenditure for these pumps during 1929 was $27.96.

Alameda Street Station—

The average cost of maintenance of boiler feed pumps in this station is now about 32.4 cents per 1,000,000 lb. of water pumped. As installed, the pumps gave considerable trouble. These pumps are of centrifugal type and leakage of air between the shaft and the packing sleeve caused the pumps to become air bound.

The sleeves were removed and the ends next to the impeller countersunk. A gasket was inserted and the sleeve was forced against the impeller with the gasket as a take-up. This eliminated all trouble due to air leakage. Stainless steel sleeves are now used as they have a much longer life than bronze, due to their resistance to corrosion when a pump is idle and, when operating, the packing does not cause grooving, if properly taken up.

Station C, Oakland—

In the 200-lb. and 250-lb. steam pressure plant we have two four-stage centrifugal boiler feed pumps, 700 g.p.m., 2,000 r.p.m., 325-lb. head, direct connected to steam turbines.

These pumps were put in operation in March, 1921, and have been in operation almost continually ever since. The top half of the casing was removed several times for inspection, but no repairs were found necessary until January, 1930, when one of the pumps was taken out of service for a general overhauling. The bronze sleeves and bushings were worn. These were renewed with Delhi rustless steel. The bronze impeller rings and casing rings were worn very little, not sufficiently to warrant renewing. Semi-metallic packing is used in these pumps with splendid results.

On the 450-lb. pressure system there are two 6-stage, 1,200-g.p.m. 570-lb. head, 1,750-r.p.m. turbine type horizontal split, iron case, boiler feed pumps of special design for high temperatures, having bronze impellers, wearing rings, diffusion vanes and shaft sleeves. Each pump is provided with internal hydraulic balancing device and Kingsbury thrust bearing, mounted on outboard bearing bracket. Pumps are direct-connected to G.E., 540-volt, variable speed, 600-hp. induction motors.

Trouble was experienced on two different occasions due to the turbine load dropping off and coming on again within a few minutes. This caused the water in the boilers to drop

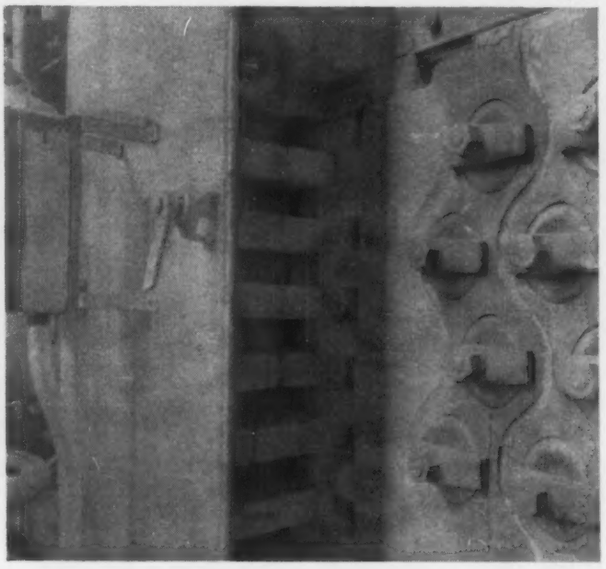

Fig. 3. Boiler No. 4 after making changes to joints between tube headers and brick setting, Seal Beach Station, Los Angeles Gas and Electric Corporation.

when the load went off, which in turn caused the feed water regulators to open and raised the water level in the boilers to such a point that, when the load came back on the system, the further natural raise in water level, due to the load coming back, caused the feedwater valve to close, thus shutting off all feedwater going into the boilers. The lack of circulation of feedwater through the extraction heaters caused the water trapped in them to reach such a temperature that it ceased to condense the extraction steam from the turbine. This blew down through the drip pumps into the feedwater pump suction which caused the feedwater pump to overheat, with the result that the bronze impeller rings and casing rings fused together, shutting down the pump.

The other pump was started up and carried the load until repairs were made. Packing trouble was experienced at the start, caused from the junk ring not fitting the shaft properly; also throat of stuffing box was larger than necessary. This allowed the semi-metallic packing to squeeze in between the junk ring and shaft, causing overheating. This was remedied by bushing the throat of stuffing box and renewing junk ring. Since then we have had no trouble with the semi-metallic packing.

Feed Water Regulators

Long Beach Plant—

The maintenance cost of feed water regulators has been negligible, but we have experienced some difficulty with the original valve port design. The trouble in plant No. 2 was remedied by using a rectangular instead of a "V" port. In Plant No. 3, differential pressure regulators were installed and the original feed water regulator plunger changed to the stream line type.

Alameda Street Station—

This plant is not equipped with individual boiler feed water regulators throughout. Two boilers are so equipped, but no cost figures are available. Both of these regulators functioned and are dependable.

Feed water pressure regulation is obtained by using differential pressure regulators on the turbine driven pumps. As all of the boiler feed pumps are turbine driven, this method of regulation of feed water has proven very satisfactory.

Station C, Oakland—

Considerable trouble has been experienced with the differential pressure feed water regulator diaphragm, due to high temperatures. We succeeded, through the experience of others, in overcoming this trouble by reducing the clearance around the stem between the body of the valve and the diaphragm. This subject is treated in some detail by the subcommittee on instruments, automatic control and plant records.

Safety Valves

Long Beach Plant—

Some difficulty was experienced with the saturated steam safety valves on plant No. 3 boilers, due principally to the design. The normal operating pressure is within four to six lb. of the maximum pressure set for the boilers, this condition causing the necessary blow-back ratio to be in excess of the steam drop desired. Also, having small margin between operating and popping pressure causes the valve to feather and has a tendency to cut or wire-draw the seat. Experiments are being conducted to determine a remedy.

Alameda Street Station—

The safety valves on the boilers have caused but little trouble. These valves are overhauled about twice a year, when the boilers come off the line for repairs and inspection.

Station C, Oakland—

We have had no trouble worth mentioning from the safety valves, but have experienced considerable trouble with the power control valve, due to the particular design of seat which screws into the body of the valve. The jarring due to the opening and closing of the valve under pressure caused the valve to leak between the seat and the body of the valve. This is being taken care of by the manufacturer, by redesigning the seat.

Economizers

Long Beach Plant—

The economizer tube failures have been mostly in the rolled joints at the tube sheet, due, it is thought, to the strain of fluctuations of temperatures during the stand-by and load regulation service.

Superheater Tube Failures

Long Beach Plant—

Shortly after putting the eight boilers of units Nos. 1 and 8 into operation in plant No. 2, they experienced considerable difficulty with superheater tube failures, due principally to poor steam distribution. This condition was remedied by installation of distribution nozzles.

Station A, San Francisco—

Superheater tube failures have been extremely rare. In six 686-hp. B&W boilers, the inlet ends of the superheater tubes had corroded and pitted considerably at the end of 20 years and it became necessary to cut off about 2 in. of the tube and then re-roll the shortened tube into the superheater cross box. There was no appreciable reduction in superheat.

Station C, Oakland—

In 1920, six 825-hp. Stirling boilers were installed with superheaters equipped with plugs in the superheater tube outlets. After a few years service the superheater tubes began to corrode from the inside at the entrance to the junction box. Upon investigation we found the tapered plug did not fit the tube properly, also the square end of the plug would not allow all condensation to drain out when the boiler was standing idle. We eliminated this trouble by making new plugs with less taper and changing the square end to a 45 degree chamfer.

Reference to data previously published in P.C.E.A. Proceedings—Boiler and Superheater Tubes—1928 Proceedings, pp. 281, 289, 290.

Turbines

Long Beach Plant—

There are no set limitations for exhaust temperature under normal operation, but a minimum of 85 deg. F. shell temperature is set during stand-by minimum load operation of units 7, 8, and 9.

The maintenance work on the main units has been principally thrust bearing trouble, high pressure seals and damaged buckets on units 7, 8, and 9. There has been one instance of blade coating, caused by the steam carrying over chemicals used in feed water treatment in unit No. 10.

Seal Beach Station—

The main units are disassembled about once every 16 months for general inspection and overhauling. The May 15, 1929 number of Electrical West, pg. 447, carries a description of the spindle turning device of our No. 1 turbine. We have since installed a 70-g.p.m. rotary pump, operated by a three-hp. vertical motor which supplies oil to turbine bearing only in connection with the above mentioned device, eliminating the need of running the less efficient turbine-driven auxiliary oil pump, with which it is, however, interconnected in such a way as to start it, should the motor fail.

Station C, Oakland—

At full load and proper vacuum, the exhaust casing temperature is 90 deg. F. to 95 deg. F. Any increase in temperature requires an investigation to determine the cause. In hot weather, during periods of low tide, the exhaust temperature will run around 105 deg. F., with all other conditions normal.

When starting the turbine, if properly done, the exhaust temperature will not exceed 150 deg. F. If the temperature exceeds 150 deg. F. when starting, it is pretty safe to assume that the vacuum is not up to the proper point.

Condensers

Long Beach Plant—

With the divided water box type, about 40 per cent of the load is usually carried when one-half of condenser is cut out. More load could be carried, but that amount seems to be the best for tolerable working conditions within the side of the condenser that is cut out.

The approximate location of a leak is found by draining the condenser to obtain a zero record on the salinometer, then the water level is gradually raised until the instrument shows salt content. Then the candle system is used to get the exact location.

Seal Beach Station—

Wheeler 40,000-sq. ft. divided water box type. Excepting such times when tube repair compels us, condensers are not operated in part.

To locate leaky tubes, the circulating water level within one-half of the condenser is slowly raised or lowered until the concentration meter on the hot well registers or ceases to register leakage. This process will fix the leak within two or three rows of tubes. Candling will then locate it definitely in short order.

Alameda Street Station—

Leaky condenser tubes are located by filling the steam space with water and opening the water space to locate the leak.

Station A, San Francisco—

We find the candle flame method of locating leaks satisfactory for the conditions at this plant.

We endeavor to keep our condensers tight, but if any small leaks show up we inject sawdust into the circulating water. This usually remedies the trouble until we are able to take the condenser out of service.

Station C, Oakland—

The method we use in locating leaking condenser tubes depends upon the size of the leak and how difficult to locate. The ordinary leak we locate by the candle method. A very stubborn leak we can some times locate by using smoke. This method is not always satisfactory.

When a leak is first discovered, provided it is not too large, we stop it temporarily by using sawdust. This generally holds good until such time as we can get at the leak to make repairs.

With one side of water box cut out, we carry from 40 per cent to 50 per cent of load; it depends somewhat on conditions, such as temperature of circulating water, which varies from 50 deg. F. to 72 deg. F., depending on the time of the year. The drop in vacuum is from 0.4 to 0.6 of an inch.

NOTE: For additional data of interest on this subject see 1929 Proceedings, Part III, pp. 67 and 68.

EVAPORATORS, EXTRACTION HEATERS, DRAINERS, ETC.

Seal Beach Station—

The "Reverse Current Valves" of the 55-lb. and 100-lb. "bleeder heaters" upon a recent examination disclosed rapid disintegration due to oxidation of the poppets which were made of duralumin, indicating that this material is entirely unsuitable for that class of service.

Station C, Oakland—

Our evaporators have been in service since October, 1928. To date we have had no operating troubles or maintenance expense of these units. We do, however, have one undesirable condition to contend with: The extraction steam for operation of the evaporators is taken from the 5th stage of the turbine and when the load on the turbine drops below 30,000 kw. there is not enough pressure in the 5th stage to operate the evaporators with extraction steam, and in that case we have to use live steam. The live steam is taken from boilers which are separate from the high pressure system, and in this way impurities are carried over into the evaporators and into the distilled water system, when using live steam. This has not been serious so far, but it might be if the practice were continued. We expect to change this soon.

Our extraction heaters went into service in October, 1928. The only trouble we have experienced with the heaters has been two tube leaks in the high pressure heater. The first occurred in November, 1929, and the second in February, 1930.

We have had considerable trouble with the drainers on No. 1 and No. 2 heaters. We have had the float arms break off, the valve get loose from the valve stem, and the drainer mechanism stick and fail to operate. We have increased the clearances as much as possible and have greatly reduced the trouble, but have decided to remove the original drainers and install another design. Considerable damage could result from the drainers sticking when there is considerable load on the turbine, allowing high pressure steam to enter parts of the system that were not designed for high pressure.

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*Heat Balance, Design and Plant Betterment**

In this report diagrams are shown illustrating the various steam cycles with theoretical efficiencies calculated for the usual operating conditions, including a study of the gains on the Rankine cycle for pressures between 200 and 3,200 lb.

By assuming the usual turbine and boiler efficiencies these results are expressed as probable plant efficiencies for the various cycles.

A method of reporting plant efficiencies is given, together with representative results and a comparison of the actual with the theoretical efficiency for the cycles and the conditions given.

The heat balance diagram presented and discussed, shows the distribution and magnitude of the heat flow for a modern station operating on the regenerative cycle. Results are calculated on a basis of heat input, and heat lost, heat recovered and heat converted to power are analyzed.

IDEAL STEAM CYCLES

FOR the past three years this subcommittee's reports have covered theoretical and actual heat balance arrangements for turbines operating on the regenerative cycle at pressures between 350 and 450 lb. gage.

For this year's work it has been suggested that the investigation be extended to cover the heat balance and efficiencies expected and obtained from the entire plants, including some of the reasons therefor, and possibly extending the study to some of the results to be expected with the higher pressures and temperatures just now coming into use.

Actual performance figures do not provide a fair basis of comparison of plant economies unless the possibilities of the particular system or cycle used are considered. It would manifestly not be right to attempt to compare a plant operating on saturated steam at 100 lb. pressure with atmospheric exhaust where 100 kw.-hr. per bbl. would probably be impossible with the 1,200-lb. reheat regenerative systems under consideration today which can easily produce as high as 550 net kw.-hr. per bbl. of oil.

Also it should be recognized that while a given plant may be capable of certain performance figures when operating at the point of maximum efficiency under steady load, any other load will be secured at a reduced efficiency and actual operating results will necessarily fall below the best tested or calculated results, depending on the nature of the load and the load factor.

When discussing plant economy it should not be forgotten that it is not steam consumption which determines the effi-

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* Report of heat balance, design and plant betterment subcommittee, prime movers committee, Engineering Section. L. J. Kraps, chairman. L. A. Hicks, V. E. Johnson, R. F. Leefeld, J. S. Moulton, C. E. Steinbeck, C. W. Wiggins.

ciency of a plant, as is often erroneously assumed, but fuel consumption and economical operation depends on the steam cycle used, the pressure and temperature employed and the amount of heat recovery equipment installed in the boiler room; and also to some extent upon the fuel used, since fuels, such as natural gas, which are high in hydrogen, unavoidably result in higher stack losses for a given exit gas temperature.

The theoretical gain to be secured by the use of various steam cycles has been thoroughly discussed by Hirshfeld, Ellenwood and others, but a brief description of the various steam cycles is included at this point to review some of the work which has been presented from time to time in other sources.

These results are usually presented in the form of the temperature entropy diagrams shown in Fig. 1 and Fig. 2, the simplest being the straight Rankine cycle without superheat, as shown in diagrams 1 to 4, inclusive (Fig. 1), for various pressures up to the critical pressure of 3,200 lb.

In these sketches condensate at 80 deg. F. at A, corresponding to ½ lb. per sq.in. absolute pressure, is heated up to the saturated temperature corresponding to boiler pressure at B, and there evaporated at constant pressure, the dry saturated steam at H expanding adiabatically through a theoretical turbine to "h" and then condensing along the line h A. The total heat absorbed in the process is represented by the total area below the feed heating line A B and the evaporation line B H. That is the area a^1 A B H h h^1, the heat rejected to the condenser being shown along the line A h, the amount being measured by the area A h h^1 a^1, the area above the line A h being theoretically available for work. The thermal efficiency of the cycle is theoretically the ratio of the heat available for work to the total heat used. In this case at 225 lb., the theoretical efficiency would be 32.8 per cent, 36.1 per cent at 500 lb., 40.1 per cent at 1,500 lb.., and 39.6 per cent at the critical point of 3,200 lb. The thermal efficiency increases with pressure up to about 1,500 lb. and then drops back until at 3,200 lb. The theoretical gain in this cycle is about 6.8 per cent greater than at 225 lb. The actual gains by pressure alone are probably considerably lower because the fluid friction losses and the wetness of the expanded steam are greater with the higher initial pressures.

In these diagrams the percentage of moisture at any point is found by drawing a horizontal line through that point from the water to the steam line and dividing the right-hand portion by the total length. Referring to diagram 4, it is seen that when steam is expanded adiabatically from the critical point it immediately becomes 50 per cent wet and maintains this percentage approximately throughout expansion. In the actual turbine the moisture would decrease during expansion, but would still be so high as to render this system impractical without superheat and reheat.

Diagram 5 showing the Rankine cycle with superheat, is the system with which all are familiar, and has been used in the older stations for some time. The efficiency of this system is limited by the upper limit of allowable temperatures which is today around 750 deg. F., giving theoretical efficiencies of around 33 per cent for 200 lb., 37.5 per cent for 500 lb., and 41.5 per cent for 1,500 lb.

The reheat cycle shown in diagram 6 adds appreciably to the theoretical economy but the process of reheating complicates the station piping.

The cycle shown in diagram 7 (Fig. 2), using isothermal expansion of the steam down to the condenser pressure, supplying heat to the steam while expanding, although probably impractical, illustrates the maximum which could be approached by using a large number of reheating devices.

Probable Plant Efficiencies for Various Cycles

Most recent installations have been on the regenerative cycle shown in Fig. 8 where some of the steam after doing useful work in the turbine is bled off to heat the feed water, the latent heat of only about 80 per cent of the steam being rejected to the condenser. Seal Beach, San Diego, Long Beach and Station "C" at Oakland are operating on this cycle.

The utilization of higher pressures has caused the adoption of the cycle shown in diagram 9 where reheat is combined with superheat and the regenerative cycle. This is the system that will be used at the new 1,400-lb. installation at Station "A" of the Pacific Gas and Electric Company, and has already been installed in a number of Eastern plants.

The special case shown in diagram 10 completes the series, showing the combination of isothermal superheating with the regenerative system. The probable relative actual plant efficiencies of the various cycles illustrated have been calculated for varying pressures at temperatures of 700 deg. F., and 1 in. absolute, the values being shown in Fig. 2.

The installation of reheat equipment adds materially to the cost of the moderate pressure plants of 400 to 500 lb. with little increase in their theoretical efficiency, but for pressures of 1,200 lb. and over it is required, due to the excessive moisture content of the steam in the lower turbine stages; the difference in cost between the high pressure reheat system and the moderate pressure system without reheat is very small while the fuel saving may amount to as much as 20 per cent in favor of the high pressure system. Due to these factors of cost and economy there will probably be few plants built for the intermediate pressures between 500 and 1,200 lb., although the upper limits of pressure for each class will be raised as the permissible steam temperatures are increased.

The boiler plant also has a decided effect on the station economy, but its results depend largely upon the expenditures justified in heat saving equipment. The economizer has been gradually replaced by the air heater for the moderate pressure regenerative cycle, since feed water heating could be done more economically by extracted steam. However, on the high pressure installations the economizer is again included and it is improbable that extraction heaters will be used on the high pressure side of the feed water systems. Regardless of the type of plant used, expected overall boiler efficiencies remain about the same, varying between 84 per cent and 90 per cent according to rating, for the newer installations, against about 75 per cent for those installed 15 or more years ago. Actual turbine efficiencies have also improved during that time, some of the best units now showing a Rankine cycle efficiency of 84.5 per cent.

Representative Results From Actual Plants

The fuel rate and efficiency of the actual plant may be determined either by test or from operating data, and for comparision should be based on the net kw.-hr. or plant output to the lines, after deducting auxiliary power.

Regardless of the system used, the results, when fuel is plotted against kw.-hr., will take the form shown in Fig. 3, the fuel-output curve resembling the familiar Willans line of turbine steam consumption. The changes in turbine economy at the point of opening of over-load valves will be reflected by changes in slope of the line. Since the various portions of these lines are very nearly straight lines it is not unusual to express them in the form of an equation as bbl. fuel $=$ a $+$ (kw. $\times$ b), which gives a figure very close to the station fuel consumption at any given load. Dividing the kilowatt output by the fuel gives the kw.-hr. per bbl., as commonly used on the Pacific Coast, and results in curves as shown in the upper portion of Fig. 3, which can readily be converted into the more universally used term of B.t.u. per kilowatt-hour.

Curves for unit 1, unit 2 and unit 3 are from test results, unit 1 being a 12,000-kw. unit with steam driven auxiliaries, open feed water heaters, oil fuel and boilers operating at

about 75 per cent efficiency. Unit 2 is a similar unit of 15,000 kw., and unit 3 is a 20,000-kw. unit with electric driven auxiliaries and economizers, boiler and economizer efficiency being about 82 per cent. The best overall thermal efficiency of these installations varied from 13.8 per cent to 16.6 per cent, operating on steam at 200 lb. pressure, superheating to a total temperature of around 525 deg. F. These units are operating under the conditions shown in diagram 5 (Fig. 1), which has a theoretical efficiency of slightly over 33 per cent. The actual plant efficiency is from 42 per cent to 50 per cent of the theoretical. Tested efficiencies were between 250 and 290 kw.-hr. per bbl.

Unit 8 is a 35,000-kw. unit, operating on the regenerative cycle at pressures around 385 lb. and temperatures of about 700 deg. F. The curve (Fig. 3) is developed from test data and supplemented by operating information, and represents a close approximation of the characteristics of this unit. The boilers are equipped with economizers. The best thermal efficiency of this plant is about 23 per cent, and the fuel economy about 420 kw. per bbl., the actual efficiency being about 56 per cent of the theoretical.

The curve for unit 9 is for a 50,000-kw. machine under approximately similar conditions except that the boilers have economizers and air heaters, the boiler efficiency being about 2 per cent better. Its over-all thermal efficiency is about 57.5 per cent of the theoretical efficiency.

The curve for unit 10 represents closely the plant performance of a 94,000-kw. unit, under steam conditions of 400 lb., 750 deg. F. on the regenerative cycle. The best over-all thermal efficiency is around 26.5 per cent, or 63.5 per cent of the theoretical, the kw.-hr. per bbl. close to 500, and the boiler efficiency on gas fuel at the high ratings carried, about 84.5 per cent.

A study of the possibilities of 1,200-lb. pressure units exhausting to the unit 10 curve shown indicates, when calculated for constant boiler efficiency and reheat to 750 deg. F., the possibility of an over-all thermal efficiency of around 30 per cent, with a fuel efficiency of possibly 550 kw. per bbl. of oil, the thermal efficiency realized being about 65 per cent of that theoretically possible with the cycle.

Heat Balance Diagram of a Modern Plant

The heat balance diagram shown in Fig. 4 shows the heat flow for a modern plant operating on the regenerative cycle, and has been compiled from test data on the 100,000-kw. tandem compound unit at the Long Beach steam plant No. 3 of the Southern California Edison Company. Steam is supplied by three 3,416-hp. boilers at 410 lb. gage throttle pressure, and total temperature of 750 deg. F. The boilers are equipped with air heaters but not economizers. The diagram is complete for the major heat distribution but no attempt has been made to separate the many small divisions of

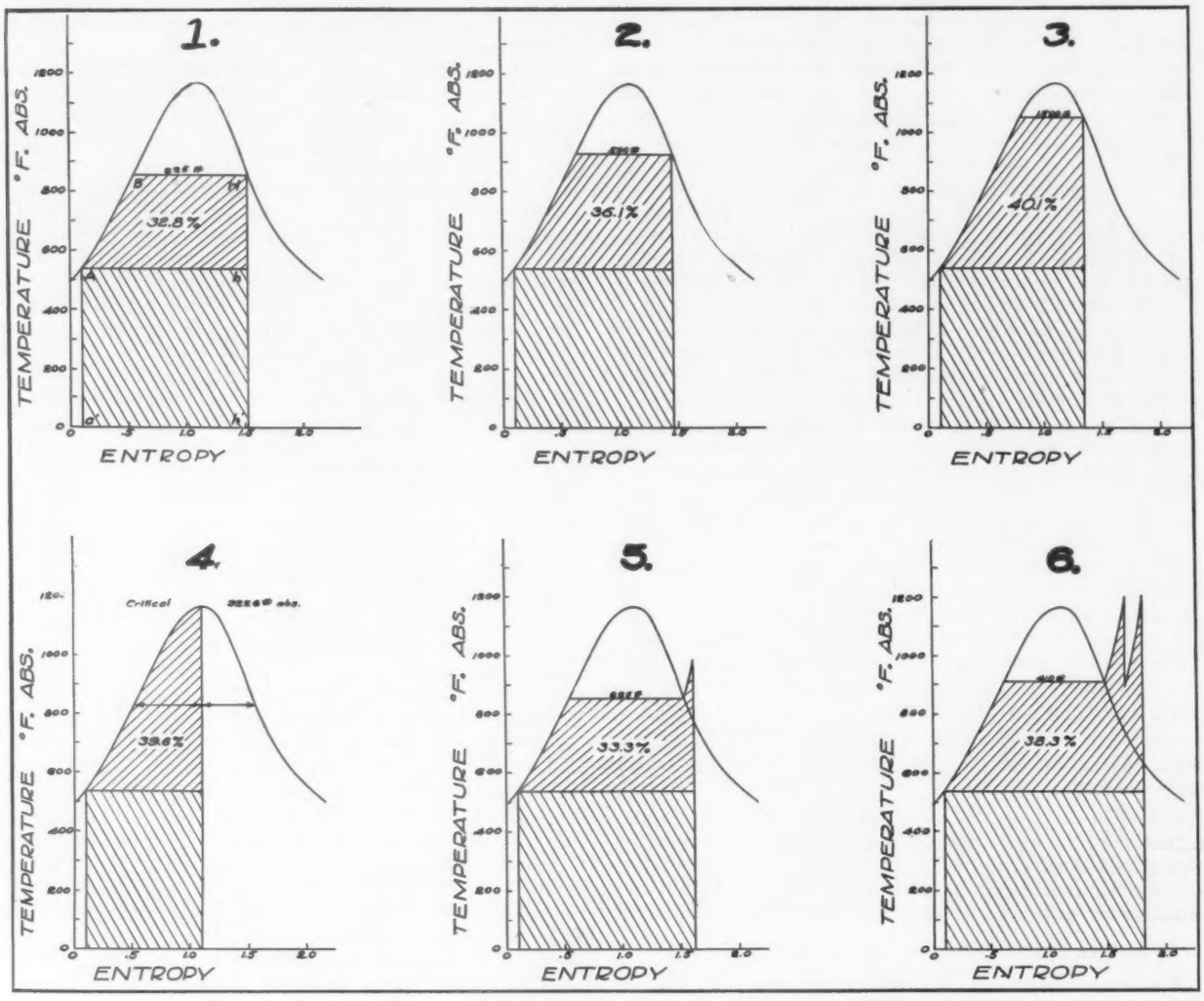


Fig. 1. Ideal steam cycles showing the effect of increased pressures on theoretical efficiency.

auxiliary power, some of which, as the power input to the forced draft fans and boiler feed pumps, is returned to the system.

The heat flow as shown in Fig. 4 may be divided conveniently into four groups: input, output, recovered heat and losses. The heat input is derived from two sources: the heat in the fuel supplied to the boilers and the small amount of heat contained in the make-up water. This latter amount is negligible (0.02 per cent) when compared to the heat input in the fuel (100 per cent). The magnitude of this group is 100.02 per cent.

The output is, of course, the electric energy delivered by the main generator to the station high voltage transformers. As shown on the diagram, the work done by the turbine or, practically speaking, the output is composed of two groups, one amounting to 3.68 per cent and the other amounting to 24.23 per cent of the heat input. The smaller of these groups represents the amount of work done by the steam that is extracted by the four feed water heaters as it flows from the throttle to the various extraction points; namely, the fifth, tenth, fourteenth and eighteenth stages. The larger of the two groups represents the power generated by the main body of steam flowing from the throttle and ultimately reaching the condenser. The total work done by the two groups amounts to 27.91 per cent of the total heat input.

There are several places in the system where heat is recovered and returned into the system. These are the air heater, the four extraction feed water heaters, main condenser hotwells, after condenser on the secondary air removal steam jets and the main generator exciter. Taking these recovered heats in the order named, the air heater returns a total of 6.53 per cent of the heat input to the system back to the boiler. This is a direct gain as it represents heat that would otherwise be lost up the stack. Of the 6.53 per cent returned as heat in the air to the furnace, 6.01 per cent is obtained directly by heat exchange within the air heater and 0.52 per cent is recovered by the forced draft fans. This latter recovery is due to the fact that the forced draft fans are mounted above the top of the boiler and are thereby in a position to recover a part of the radiation loss from the boiler.

A very considerable portion of the total heat input to the boiler is that supplied as heat in the feed water. This heat is recovered by the four extraction feed water heaters and the reheating hotwells, for the most part, and is heat that would otherwise be largely lost in the condenser.

The heat returned by the four feed water heaters amounts to 27.18 per cent and that by the water leaving the condenser hotwells 3.47 per cent. This latter figure contains a small amount of heat extracted from exhaust steam by the reheating hotwells which are connected directly with the exhaust steam space of the turbine.

The steam from which the heat is extracted by the four feed water heaters also contributes to the work done by the turbine to the extent of 3.68 per cent as mentioned above. By this extraction process the economy of the unit is im-

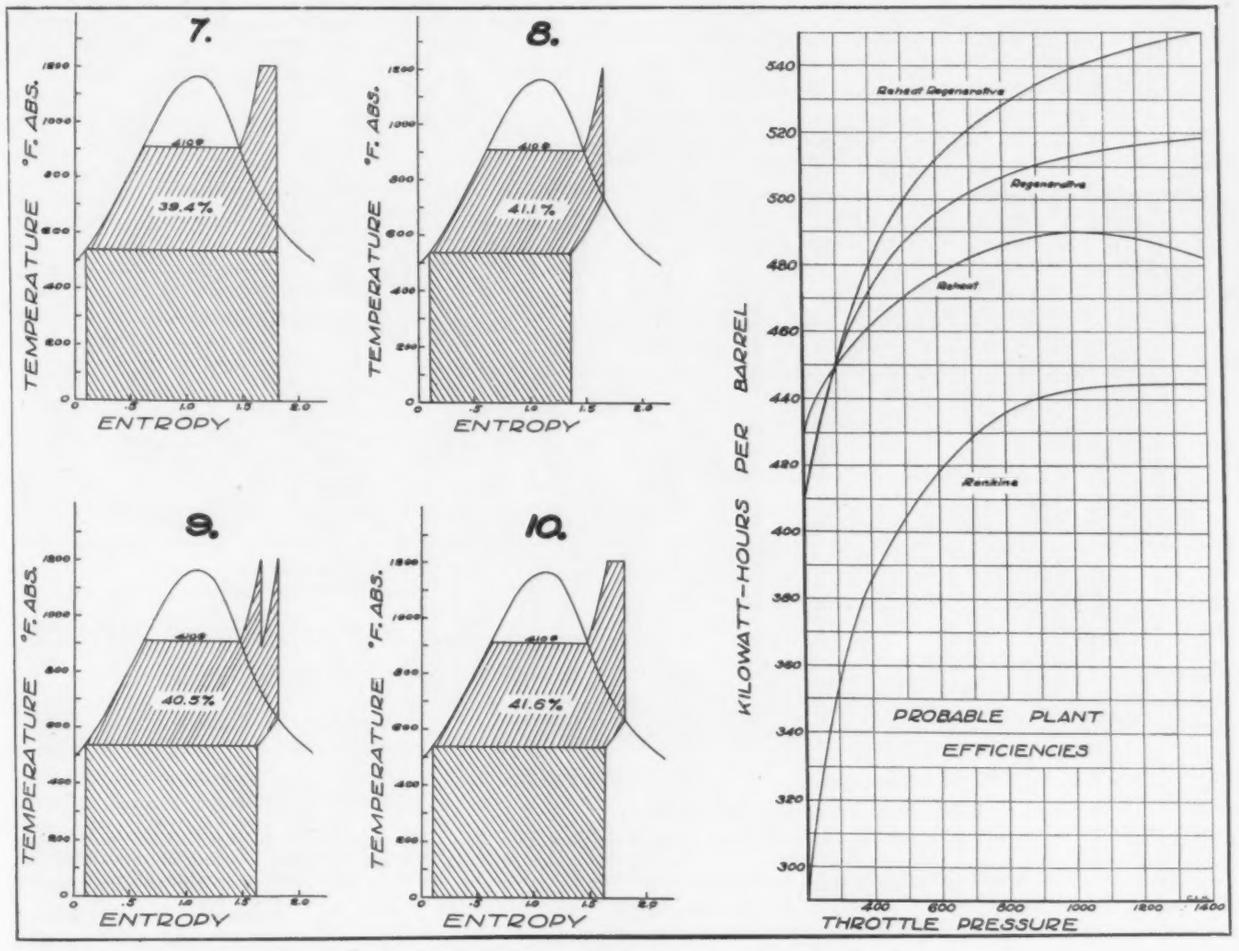


Fig. 2. Ideal steam cycles for superheat, reheat and extraction with probable actual efficiencies of plants operating on various cycles.

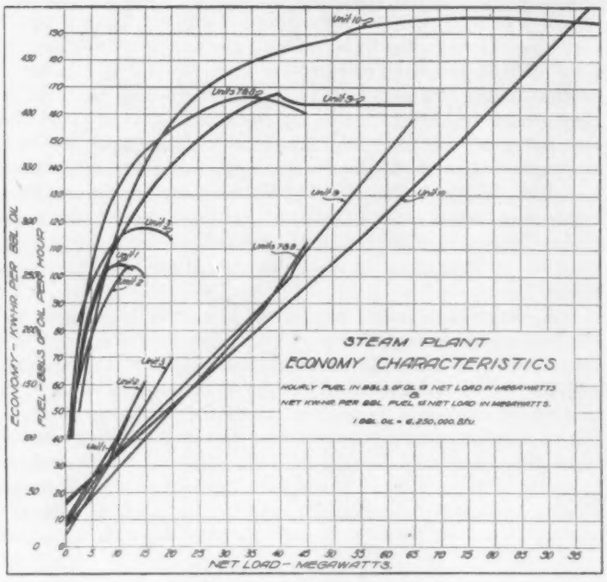
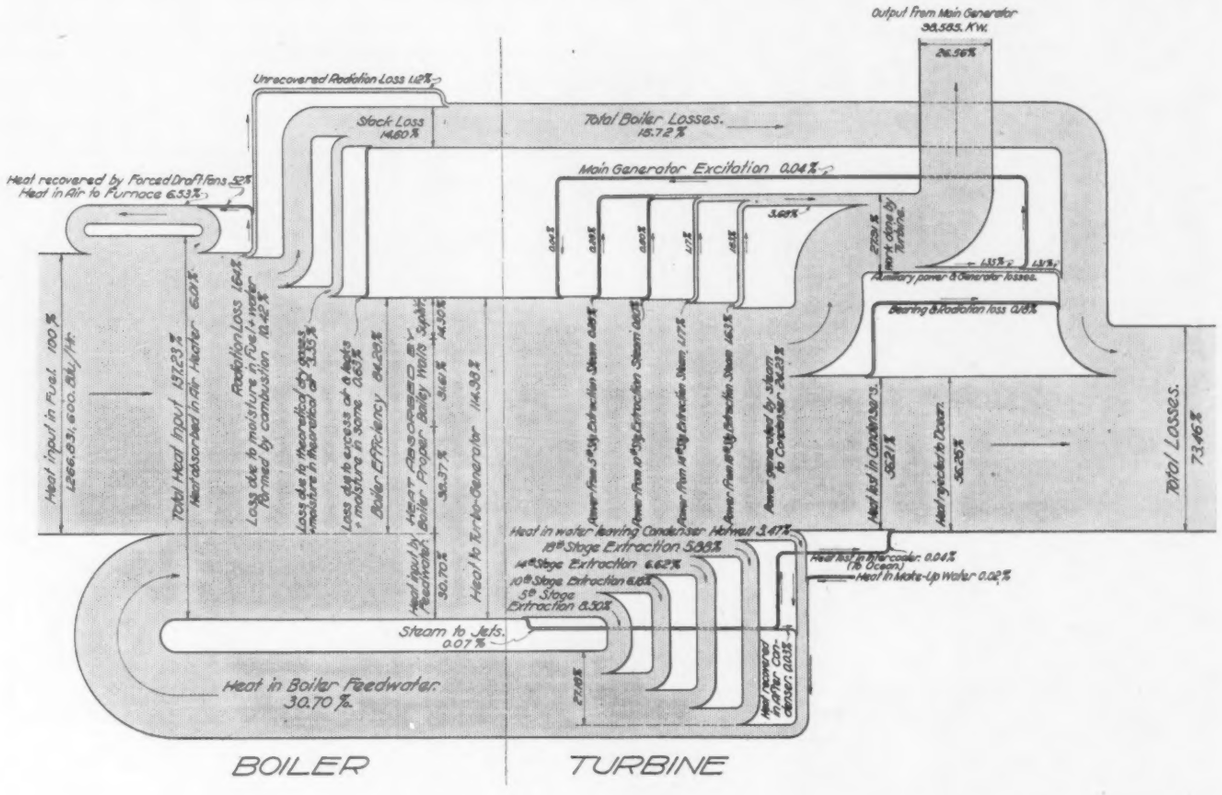

STEAM PLANT
ECONOMY CHARACTERISTICS
HOURLY FUEL IN BBLS. OF OIL @ NET LOAD IN MEGAWATTS
NET KW-HR. PER BBL. FUEL @ NET LOAD IN MEGAWATTS.
1 BBL. OIL = 6,250,000 B.t.u.
NET LOAD - MEGAWATTS.

Fig. 3. Steam plant economy characteristics.

proved to a considerable degree. If the turbine were to operate on a straight condensing non-extraction cycle, its gain in capacity over that obtained by full extraction would amount to about 19 per cent and at the same time its loss in economy would be approximately 10 per cent for the conditions shown on the diagram. The fact that the heat entering the turbo-generator contains approximately 15 per cent more heat than that contained in the fuel is due to the large amount of heat returned in the feed water.

A small amount of heat (0.03 per cent) is recovered in the after condenser by using condensate to absorb the heat in the exhaust of the secondary air removing steam jets. The main generator excitation is also recovered from the station auxiliary power system, although this amount is quite small (0.04 per cent).

The last main group of heats shown on the diagram, namely, the losses, is by far the largest and consists of boiler losses, turbo-generator losses and condenser losses. The boiler stack loss consists for the most part of loss due to moisture in the flue gas. This large amount of moisture is due to the presence of a considerable amount of hydrogen in the constituents of the natural gas fuel. For each pound of fuel burned there is formed approximately 2 lb. of water in the flue gas which leaves the stack in the form of superheated steam, causing a moisture loss of approximately 10 per cent. The other components of stack loss, namely, the loss due to theoretical dry gases and excess air, amount to 4.18 per cent.


Output from Main Generator 98,585 K.W.
86.56%
Unrecovered Radiation Loss 1.12%
Stack Loss 14.60%
Total Boiler Losses. 15.72%
Main Generator Excitation 0.04%
Heat recovered by Forced Draft Fans 52%
Heat in Air to Furnace 6.53%
Auxiliary power & Generator losses.
Bearing & Radiation loss 0.8%
Heat input in Fuel 100%
Less 6.5% 600 Btu/lb.
Total Heat Input 137.23%
Heat absorbed in Air Heater 6.03%
Radiation Loss 1.64%
Heat in water leaving Condenser Hotwell 3.47%
18th Stage Extraction 5.66%
14th Stage Extraction 6.62%
10th Stage Extraction 6.62%
5th Stage Extraction 8.50%
Steam to Jets. 0.07%
Heat in Boiler Feedwater 30.70%
Heat lost in Aftercooler 0.04%
(to Ocean)
Heat in Make-Up Water 0.02%
Total Losses. 73.46%
BOILER
TURBINE

Conditions: Gross load 101,585 kw. Transmitted or net load on main generator 98,585 kw. Heat input in fuel, 100 per cent equals 1,266,831,600 B.t.u. per hour. Boiler rating 311.34 per cent. Feedwater temperature 393 deg. F. Steam pressure at throttle 400 lb. per sq.in. gage. Steam temperature 370 deg. F. Back pressure in condensers 1.33 in. mercury. Steam flow at throttle 1,054,458 lb. per hour. Efficiency: 486.37 net kw.-hr. per bbl. oil, or 12,850 per net kw.-hr., or 26.56 per cent.

Fig. 4. Heat balance diagram of a modern moderate pressure plantshowing heat input, heat lost and recovered and heat output in the form of available electric energy.

The turbo-generator losses, together with the auxiliary power not used for main generator excitation, amount to 1.49 per cent.

About 73 per cent of the steam flow at the turbine throttle finds its way to the condenser and the remaining 27 per cent is extracted by the four feed water heaters. This 73 per cent of the throttle steam flow generates power amounting to 24.73 per cent of the total heat input to the system and gives up 56.21 per cent of the total heat input as a loss to the circulating water in the condenser. It should be noted that the heat lost in the condenser should be expressed as a percentage of the fuel input to the boilers rather than as a percentage of the heat input to the turbine as the latter basis will give a figure somewhat smaller than the former. As costs depend upon fuel input, the true magnitude of the heat wasted in the condenser can be obtained only by placing it on the fuel input basis. For the case in hand, the heat lost in the condenser is 56.21 per cent of the heat input in fuel, whereas it is about 49 per cent of the heat input to the turbine throttle, a difference of about 7 per cent.

In calculating the yearly economy for this plant it was found that for operation during the year 1929, the over-all thermal economy was 26.56 per cent, as shown on this diagram, so it is somewhat of a coincidence that this is representative of the last year's operation.

Generalizing, we may say that about one-fourth of the total heat input is obtained as useful output while three-fourths is lost.

In studying the characteristics of this plant it became evident that the boiler performance, where only two or three large boilers are used, has a marked influence on the turbine performance, particularly the change in steam temperature since this must necessarily fluctuate with the boiler rating.

Although we pride ourselves today on the creditable showing we are able to make with the more modern plants and the very remarkable progress that has been made in recent years, the necessary wastefulness of even the most efficient systems is appalling and the equipment and investment required to secure the comparatively insignificant savings are a burden on all industry. Science is continually perfecting new and more economical methods of utilization, most of the present-day efforts being to increase the amount of available heat that can be crowded into the cycle without increasing the losses. While the binary systems, such as the mercury vapor process seem to offer promise, the greater losses in the flue gases and circulating water still remain as a burden which must be carried until such time as electrical energy can be secured directly from fuel. While this now seems visionary, the fundamental structure of matter and energy are rapidly becoming better understood and the time may come when the wonder will be that the simplicity of the process remained undiscovered for so long.

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*Water Conditioning and Power Plant Chemistry**

This report contains a statement of the requirements for current boiler water conditioning, a description of some of the more recent short methods of analysis for routine control, a discussion of the subject of carry-over of impurities from boilers and a description of the system of water conditioning in use at the Seal Beach Station of the Los Angeles Gas and Electric Corporation.

* Report of water conditioning and power plant chemistry subcommittee of prime movers committee, Engineering Section. August Sattler, chairman. G. H. Briggs, P. E. Chapman, Scott Jensen, Weiler Reed, C. P. Rhine, F. B. Stillwaggon.

Requirements for Correct Boiler Water Conditioning

THE growing tendency during the past few years toward higher pressures and higher ratings has called for more exacting methods of feedwater control. It is obvious that the higher the pressure and especially the rating carried, the greater will be the tendency toward scale formation, and solids carried over in the steam. This demands a minimum amount of incrusting solids going to the boilers from whatever treating system is in use, and the blow-downs carefully regulated.

Not only does each water present a different problem, but each plant has its own peculiarities, for each boiler is a chemical vessel and should be controlled by intelligent chemical treatment.

In order to keep the total dissolved solids of the boiler water as low as possible and yet maintain the prescribed sulphate-alkalinity ratio, it is necessary to maintain as little alkalinity as possible and still prevent corrosion.

Keeping the sulphate-alkalinity ratio up to A.S.M.E. boiler code rulings, and the oxygen content practically eliminated, does not prevent corrosion. For, unless the hydroxide alkalinity is maintained at not less than 25 parts per million or 1.5 grains per gallon, corrosion may take place.

Also in water containing considerable sodium bicarbonate and free carbon dioxide, corrosion is likely to occur, even though the oxygen content is exceedingly low. Distilled water, even when free from oxygen, may be corrosive; because when it is heated to boiler pressure and temperature, its pH value decreases appreciably.

Hydroxide alkalinity will not prevent the formation of sulphate scale but is a preventive of silicate scale, forming soluble sodium silicate. Phosphate treatment at pressures above 200 lb. per sq. in. is more effective than soda ash or caustic soda for the prevention of scale, because of the lesser solubility of the calcium and magnesium phosphate.

The ultimate aim of the treatment to prevent caustic embrittlement is to maintain within the boiler a predetermined amount of the inhibiting chemical. The two chemicals which are receiving most attention in this respect are sodium sulphate and sodium phosphate. A definite amount of either of these salts must be maintained in the boiler water. The sulphate is kept in direct proportion to the total alkalinity in the boiler water, while the phosphate is usually kept at a definite figure, which is largely independent of total alkalinity for normal concentrations.

Of the phosphates, the tri-sodium containing 25 per cent PO_4 is generally used. The di-sodium phosphate is less alkaline and containes 26 per cent PO_4. The mono-sodium phosphate or acid phosphate containes 70 per cent PO_4 and is used to reduce the alkalinity and at the same time increase the PO_4.

The work of Professors Parr and F. G. Straub of the University of Illinois, indicates that probably the presence of a comparatively small amount of phosphate will inhibit caustic embrittlement, and is about 500 times as effective as sulphate in preventing embrittlement. The hydroxide alkalinity must not fall much below 25 p.p.m., otherwise the increasing solubility of calcium phosphate and the decreasing pH value may cause calcium sulphate to deposit as scale.

The Southwestern Public Service Company, Amarillo, Texas, reports discontinuing the use of sulphate since April, 1928, and makes use of phosphate for inhibiting embrittlement and preventing scale formation. The boilers were emptied of all water containing sulphate and filled with water containing only sodium phosphate and caustic soda. Since that time the boiler water has contained between 30 and 50 p.p.m. of free soluble phosphate and pH value of

about 10. The advantage of this method is that the concentration of the total solids can be kept at a very low figure. With such a low concentration of solids, turbine blade scale will be slow in forming. The boilers are 2,000 hp., and 400 lb. pressure, and have operated for eighteen months without the presence of sulphate in appreciable amounts. They have been free from scale, corrosion, caustic embrittlement and no blow-downs have been necessary.

By maintaining low concentration of hydroxide in the boiler water the concentrations of sulphate need not be extremely high for the maintenance of the sulphate-alkalinity ratio required to meet the recommendations of the boiler code on prevention of embrittlement. This is beneficial because the artificial addition of sulphate is less frequently necessary, giving lower concentration of dissolved solids in the boiler water and improving boiling conditions.

From the standpoint of stability the phosphates meet all requirements. Since phosphates do not decompose, and also increase the alkalinity of the boiler water, this alkalinity can be maintained at a very low value and consequently there is little reason to fear caustic embrittlement. The most favorable pH value can thus be maintained to prevent corrosion and at the same time permit protection from caustic embrittlement without the use of a large quantity of sulphate. This method of treatment produces clean surfaces, clear water and good steaming conditions, giving extremely low concentration of dissolved solids. Where the make-up is evaporated and the raw water leakage is not excessive, the total dissolved solids should not exceed 1,000 p.p.m. or 50 to 60 grains per gal.

In addition to maintaining low hydroxide concentration every effort should be made to exclude from the boiler water all saponifiable materials as grease, oil and sewage contamination, these causing priming.

Short Methods for Making Routine Analyses

In order to be assured that the treatment is being properly administered, control of the water treatment must be maintained by rapid and fairly accurate methods of analysis. The most desirable analyses to be run on the boiler water sample are alkalinity, sodium chloride, phosphates or sodium sulphate, depending on the conditioning used, and oxygen.

The alkalinity of a water indicates the presence of certain salts in solution, which have the power to neutralize acids. The alkaline salts may be present in a number of different forms. The ones usually present in boiler feed waters are known as carbonates, bicarbonates, and hydrates, sometimes called hydroxides. One or two of these forms of alkalinity may be present in a water, or there may be a change from one form to another during chemical treatment or under the influence of heat.

It is desirable for the plant engineer to know not only the amount of total alkalinity of his boiler water, but also the amount of each kind of alkalinity. He should know what parts of the alkalinity in the water tested are present as carbonate, bicarbonate and hydrate alkalinity. These tests are comparatively simple and may be readily made.

Tests for Alkalinity

The usual methods of determining alkalinity are so well known that they need not be repeated here. Descriptions of these tests have appeared in various publications, including th A.S.M.E. Boiler Construction Code for 1927, Section VII, p. 86. The relative amounts of akalinity in the form of bicarbonates, carbonates and hydrates may be calculated from the two alkalinity readings obtained with phenolpthalein and methyl orange. These data were published in the 1927 Proceedings of the Pacific Coast Electrical Association, p. 247 and also in "Standard Methods of Chemical Analysis" by W. H. Scott (fourth edition, 1925,) pp. 1429 and 1430.

The determination of carbonate and hydrate alkalinity of concentrated boiler water by the ordinary titremetric method is reliable only in the absence of appreciable amounts of organic matter when the water is relatively clear. When concentrated boiler waters contain an appreciable amount of organic matter in solution or suspension, or where the water is turbid or highly colored, these determinations should be made by the Winkler method as follows:

In one portion determine the total amount of alkali present by titration with acid, using M.O. as an indicator, which gives all the hydroxide and the carbonate. In a second portion determine the hydroxide thusly: To the solution add an excess of neutral barium chloride solution, when the following reactions take place:

$$Na_2CO_3 + BaCl_2 = 2NaCl + BaCO_3 \text{ (insoluble)}$$
$$2NaOH + BaCl_2 = 2NaCl + Ba(OH)_2 \text{ (soluble)}$$

Then add phenolpthalein indicator and titrate slowly with acid with constant stirring; decolorization is effected from a red to a colorless solution as soon as the hydroxide is neutralized and before any barium carbonate is dissolved. The amount of acid used corresponds to the amount of hydroxide originally present.

Example:

1. 100 c.c. ($Na_2CO_3 + NaOH$) require (x) c.c. 0.1 normal acid for $Na_2CO_3 + NaOH$.

2. 100 c.c. ($Na_2CO_3 + NaOH$) require (y) c.c. 0.1 normal acid for NaOH alone, so that 100 c.c. ($Na_2CO_3 + NaOH$) require (x-y) c.c. 0.1 normal acid for Na_2CO_3. 100 c.c. of the solution therefore contain (y)x 0.004 gram NaOH and (x-y) x 0.0053 gram Na_2CO_3. Care must be taken when adding the acid in the titration; unless it is added very slowly some of the barium carbonate will be acted upon before the end point is reached.

Test for Chlorides—

The term "chlorides" is used to express the combination of chloride with other elements forming salts that are comparatively stable and not easily broken up under ordinary conditions. The term "chlorides" is to be distinguished from "chlorine" such as liquid chlorine used extensively for sterilization of public water suppliees. The test for chlorides is well known and a description of it may be found in the A.S.M.E. Boiler Construction Code for 1927, Section VII, p. 87.

Test for Oxygen—

The test for dissolved oxygen is the well known Winkler method which was described in the last issue of the National Prime Movers Bulletin, February, 1929, Treatment of Feedwater, Publication 289-28.

Test for Sulphates—

The standard gravimetric method for the determination of sulphate is not applicable for routine work in determining the sulphate content of concentrated boiler water, principally because the method is time consuming and the accuracy which it affords is not ordinarily required for plant control.

The turbidimeter method is sufficiently accurate for determining the sulphates in boiler water, and has the added advantage that it is fairly rapid and requires no special technique. The method consists of measuring the turbidity produced by precipitating the sulphates by means of barium chloride in a slightly acidified solution. The finely divided barium precipitate is measured by limiting the depth of solution through which a standard light can be detected. The apparatus is standardized against solutions of sulphates of known strengtth.

A somewhat similar method has been in use in which the sulphates are precipitated by barium chloride and the concentrated turbid solution is diluted by distilled water until a standard light becomes visible. The degree of dilution is a measure of the amount of sulphates present in the original sample.

Although these methods are of value on account of the rapidity with which they can be made, there are some objections to them. The conditions under which the precipitations are made have a marked effect upon the barium sulphate precipitate. The accuracy of the test should be checked from time to time by gravimetric determinations. Considered broadly, however, the turbidity method for routine determination of sulphates may be used to advantage.

Test for Phosphate—

For the determination of the phosphate, a method has been developed by Professor Straub given in detail in "Mechanical Engineering," May 1929, which depends on the fact that molybdenum present as phosphomolybdic acid may be reduced in the presence of an excess of molybdic acid. The reducing agent used is hydroquinone. If hydroquinone is added to an acid solution of molybdic acid, no phosphate being present, the solution will be colorless when treated with alkaline sulphite, but if phosphate is present, phosphomolybdic acid is formed and reduced, giving a blue color. As small an amount as 5 p.p.m. of phosphate gives a distinct blue color in this test.

The standard method for the determination of phosphate involves the precipitation of the phosphate as phosphomolybdate in a nitric acid solution of definite acidity with an excess of ammonium nitrate present at a temperature of about 80 deg. C. or 175 deg. F. The filtrate is washed with a 1 per cent solution of potassium nitrate. The washed precipitate is ignited and weighed, or it is dissolved in standard nitric acid. This method is not suitable for boiler room control, except as a check method. It has been modified to the point where the precipitate instead of being filtered is allowed to settle in a glass tube having a calibrated capillary tube at the bottom. At the Long Beach steam plant we have developed the following method which is much simpler and quicker:

Place 100 c.c. of the boiler water sample in which the PO_4 is to be determined in a 100 c.c. centrifuge tube (which ordinarily holds about 125 c.c.) and make it slightly acid with concentrated nitric acid; then neutralize with concentrated ammonium hydroxide, and add a few c.c. of nitric acid. This will give the ammonium nitrate necessary for the precipitation of the phosphate and also acidify the alkalinity of the boiler water, another needed step. Then add 10 c.c. molybdic acid solution; shake the tube by hand and place in centrifuge used for the determination of water and sediment in oil. Then centrifuge about 5 minutes. The volume of precipitate which settles is a measure of the phosphate content. The volume occupied by fractions of a c.c. of the precipitate is previously determined with a known amount of sodium phosphate.

This phosphate in the boiler water is combined with sodium and in the presence of sodium hydroxide is combined as tri-sodium phosphate which is ordinarily calculated with the total alkalinity as sodium carbonate. To bring the sulphate-alkalinity ratio to the real condition as it is in the boiler water, allowance must be made for the alkalinity existing as sodium phosphate.

The high pressures and high temperatures existing today in the modern plants render the boiler equipment particularly liable to corrosion and embrittlement. The large investments in this equipment make it necessary to observe the closest control of these conditions and this control must necessarily continue until such time as science can either provide materials or boiler construction which will not be liable to attack or furnish us a universal cure-all in the way of a boiler compound which will be safe to use in inexperienced hands.

Overcoming Difficulties With Carry-over From Boilers

In Power Plant Engineering, December 15, 1929, some difficulities were reported on account of the carry-over of the treatment chemicals. This was overcome by the installation of steam purifiers in the boiler drums to remove the impurities in the steam, and by employing continuous blowdown in connection with heat exchanges.

Corrosion of non-ferrous metals in bleeder heaters and evaporator condensers has been encountered and overcome in the heaters by additional de-aeration of the water and venting of equipment. Correction of corrosion in evaporator condensers has been made by the installation of an open heater on the evaporator feed in order to reduce the amount of gases that would otherwise be discharged to the evaporator condenser.

Corrosion in the hot boiler feed lines and in the boilers has been eliminated by the simple expedient of recirculating sufficient blow-off water, which is highly caustic, back into the water space of the heater. By this means all free CO_2 in the initial water is converted into sodium carbonate, and the sodium bicarbonate also is converted into sodium carbonate, thus making the water non-corrosive.

Besides causing erosion, the impurities carried over with the steam may lead to severe corrosion, depending upon their nature and upon the material of which the turbine blades are constructed. Caustic soda, which is probably used more than any reagent for internal treatment of boiler water, may be expected to cause corrosion of blades constructed of copper alloy.

Corrosion of turbine blading may lead to corrosion of the boilers under certain circumstances. An interesting example of this was given some years ago in the Journal of the American Society of Naval Engineers by Commander J. E. Palmer. The boiler was of the water-tube type and was used on board a vessel equipped with a Parsons turbine. After only about two months' service, a number of the water tubes failed as the result of pitting, and the boiler had to be retubed after four months.

An examination of the defective tubes showed a brownish deposit about the pitted parts. An analysis of the deposit indicated the presence of copper. How the copper had gained entrance to the boiler was not at first evident, but on examination of the turbine it was found that the blades, which were of bronze containing a high percentage of copper, had suffered a certain amount of erosion. The eroded metal had evidently been carried away by the exhaust steam into the condenser from whence it had passed into the feedwater, and so into the boiler. The presence of the copper in the tubes thus set up galvanic action, which in turn caused pitting of the tubes.

Attempts to keep concentration of solids low in boiler water by excessive blowdown are extravagant and of little avail. Nor can boiler water concentration be prevented. Neither can boilers be made to generate steam without tending to carry some actual water and impurities with the steam. The result of boiler concentration is therefore the production of impure steam with attendant danger, trouble and expense throughout the entire power plant. Consequently, more attention should be paid to dealing with this result. In other words, since steam cannot be generated that is pure, steps should be taken for the complete removal, mechanically or otherwise, of the impurities from the steam.

Carry-over from Boilers at Station A—Statement by Pacific Gas and Electric Company—

At heavy loads this station has always experienced some trouble with carry-over from the boilers. The evidence of this shows up chiefly as deposits on the turbine blading although small deposits are sometimes found on the steam jet air pump nozzles.

The greatest trouble was experienced during the heavy load period of 1924 and finally resulted in a marked reduction in the maximum load that could be carried on the turbines. When the turbines were overhauled the following year large deposits were found on the turbine blading. Con-

centrations in samples of condensed steam have run as high as 6 grains per gallon. Due to the very light load conditions during the next three years the effects of carry-over were only slightly noticeable, but some attention was given to the matter of reducing the possibility of a recurrence of similar trouble in case of another dry year.

We have not been able to examine the blading in any of our turbines since the return of heavy load conditions brought about by the recent water shortage, but we have had definite indications that solids are still being carried over with the steam. Small deposits have been found on the steam jet air pump nozzles, but we believe the amount of carry-over into the main turbines has been very small because there is no noticeable reduction in maximum load and there has been no change in stage pressures.

It is agreed that the amount of solids carried over with the steam is usually a function of the amount of concentration of solids in the boiler water. Our program, therefore, was first to obtain a more uniform control of boiler blowdown and second to hold the boiler water concentration at a lower figure. Our complete program was as follows:

1. Installation of a continuous blowdown system to make uniform control of boiler water concentration possible.
2. Increase in amount of blowdown in order to reduce average boiler concentration. We hold our sodium chloride concentration at about 50 grains per gal., which is equivalent to from 70 to 90 grains per gal. total solids.
3. Reduction of condenser leakage. Any leakage from this source necessitates supplementary feed water treatment in the hotwells or in the boilers in order to eliminate scale-forming solids. Both the leakage and the additional treatment tend to raise the concentration of the boiler water and also add to the material in suspension.
4. Installation of a steam purifier either in each boiler drum or in the steam line to each turbine. In an old plant of this type where there are many more boilers than turbines, the second plan would probably be the only one that could be justified from an economic standpoint.

All the items in the above program have been carried out except the last one. Due to the short length of time that the old equipment will remain in service before dismantling we feel that the changes we have already made are all that are now economically justified.

Water Conditioning Practice at Seal Beach Station—Statement by Los Angeles Gas and Electric Corporation

The steps by which, at this plant, well water is converted to make-up water include the following:

1. Treating with alum to insure clarification during filtering.
2. Filtering through sand.
3. Passing through a zeolite softener.
4. Evaporating.
5. Passing, as vapor, through a separator to remove entrained spray.
6. Condensing.

Alum Treatment—

Alum is added to the well water to produce a gelatinous suspension (floc) which coagulates or catches the fine particles. In order to produce satisfactory filtered water, it has been found that the M.O. alkalinity must be reduced from 6.9 grains per gal. (in terms of Na_2CO_3) to 5.1 grains per gal. With an average make-up of about 13,300 lb. per day, the alum required is about 0.8 lb. per day. The alum water is fed to the well water before entering the filter. The grade of alum used is described as "commercial aluminum sulphate, not iron free, walnut size lump."

Sand Filter—

After treating with alum, the water passes through a sand filter which strains out the floc with the entrained particles, thus producing clear water. This filter is backwashed about once per week, about thirty minutes being required.

Zeolite Softener—

After filtering, the water passes through a zeolite softener. Changes in well water by filtering and softening are shown below. It is interesting to note that tests of the well water do not show a change from month to month. Changes from year to year are within the error of the analysis:

TABLE I—Changes After Filtering and Softening.

Hypothetical Combination	Grains per U. S. gallon Natural	Softened	Change
Suspended matter	None	None	
Silica	1.05	1.45	Plus 0.40
Iron oxide and alumina	0.30	0.14	Minus 0.16
Calcium carbonate	0.91	0.07	Minus 0.84
Calcium sulphate	Trace	None	
Calcium chloride	None	None	
Magnesium carbonate	0.17	0.12	Minus 0.05
Magnesium sulphate	None	None	
Magnesium chloride	None	None	
Sodium carbonate	8.74	9.71	Plus 0.97
Sodium sulphate	1.06	1.24	Plus 0.18
Sodium chloride	1.73	1.73	
Total solids	13.96	14.46	Plus 0.50

Evaporating—

The softened water flows to the evaporators through manually controlled valves. There it is converted to vapor by steam coils heated by steam bled from the turbine at about 50 lb. pressure.

Intermittent blowdown is used. When the liquor remaining from the evaporation becomes so concentrated that there is danger of foaming, it is discarded and the evaporators refilled with new water.

The vapor rising from the turbulent surface of the liquor necessarily entrains considerable spray that originates from the bursting bubbles at the liquor surface. Much of this settles out while the vapor is yet in the steam dome of the evaporator, which is merely a continuation of the evaporator shell, of about equal height.

The vapor leaves the top of the steam dome carrying about ¾ per cent of liquor in suspension and shows about one grain per gal. of total solids.

Passing as Vapor Through Separators—

From the steam dome, the vapors pass through separators which throw down much of the entrained liquor by centrifugal action and surface contact. This returns by gravity to the evaporator.

The separators were installed as a result of evidence that the vapors delivered by the evaporators contained over the desired maximum of one-half grain per gallon.

Comparative tests of vapor in and out of these separators showed the following:

	In Grains Per Gal.	Out Grains Per Gal.
Carbonates (as of Na_2CO_3)	0.00	0.00
Bicarbonates (as of $NaHCO_3$)	0.28	0.24
Chlorides (as of NaCl)	0.19	0.18
Total solids by evaporation	0.817	0.507

From these tests it is seen that the separators reduce the amount of total solids in the vapor leaving the evaporators about one-third, and that the desired purity was approximated only after installing separators.

Condensing—

The vapor, as it leaves the separators, is condensed by mingling it with low pressure steam that is on its way to a feedwater heater where its latent heat of evaporation is delivered up. The condensate, which then contains the condensed evaporator vapor, is picked up by a pump and passed directly into the feedwater system.

Equipment—

The equipment used is as follows:

One alum pot, for use in connection with the following softener.
One zeolite water softener, vertical single unit, 3 ft. diameter, maximum rate of softening 35 g.p.m.
One water purification apparatus (sand filter).
Two evaporators, single effect type, vertical, submerged, ellipticoil, capacity 7,500 g.p.m.
One conductivity instrument recording the concentration of the vapor leaving evaporators in grains per gal. in terms of Cl.
One conductivity instrument recording the concentration of the liquor in the evaporators in grains per gal. in terms of Cl.
Two 10-in. separators, straight way, external purifier, capacity approximately 7,500 lb. of vapor per hour.
Two bleeder low-pressure feed water heaters, condensing type.

The equipment is highly satisfactory and requires a minimum of attention for a system of this sort.

UNDERGROUND SYSTEMS COMMITTEE REPORTS[2]

Temperature and Its Relation to Underground Systems

By PAUL SURANSKY*

This paper is a brief summary of three reports which were prepared for the underground systems committee Engineering National Section, N.E.L.A. The purpose of the paper is to provide the members of the Engineering Section of the P.C.E.A. with information relative to those studies which deal with temperature and its relation to underground systems, as made by the national committee. By furnishing such information, it is expected that members of this section will not duplicate the efforts of the national committee and in addition thereto that before making temperature surveys on an underground system, they will first contact the national committee. This contact should be made so that they may profit by that committee's experience and also that uniform methods for taking temperature measurements will be used in order that results of such investigations of the various operating companies in the United States may readily be compared and combined and proper conclusions deducted therefrom.

The three reports which will be covered in this paper are: 1. Earth Temperatures and Their Use in Rating Cable, 2. Conduit and Manhole Temperatures, 3. The Calculation of Cable Temperatures in Subway Ducts.

UNDERGROUND transmission and distribution systems are being continually extended, and large amounts of new capital are invested each year in the conduit and cable systems, which such extensions require. It is economically necessary that such systems be operated with the minimum investment per kilowatt of load. To accomplish this requires the utmost utilization of all component parts of the system. Since it has been found that the maximum amount of energy that can be transmitted over a given underground system is limited by temperature, it becomes necessary to make detailed investigations of temperature and its relation to underground systems. For these reasons the three reports previously mentioned have been prepared. A discussion and the conclusions of each report follows.

Earth Temperatures and Their Use in Rating Cables

In the rating of underground cables the correct determination of the base earth temperature is essential for accuracy of cable temperature predetermination. The earth temperature in cable operation bears the same relation as the ambient air temperature does in rating electric machinery. In calculating cable ratings several temperature gradients, namely, the rise of copper above sheath, the rise of sheath above duct and the rise of duct above earth are calculated. When the summation of these individual temperature rises are added to the earth temperature, the copper temperature is obtained, which determines the rating of the cable.

If the base ground temperature is low, the rise from earth to copper and hence the current carried by the conductors, may be increased. Naturally the converse of this is true. Therefore, an accurate record of the ground temperature and the seasonal variation thereof is of primary importance to any company operating an underground transmission or distribution system, so that the maximum amount of energy may be carried by the cable system without exceeding the limits imposed by safe operation, thus operating with the minimum investment per kilowatt of load.

With varying soil conditions it may be necessary to obtain seasonal data for several locations on one system. This is particularly true when duct lines are installed under differing conditions such as under paving near buildings, especially those having extensive subsurface volume.

Methods of Measuring Earth Temperatures—

Measurements of earth temperatures have been made and reported by eleven companies. These various companies reported three methods of taking earth temperature measurements, namely, by long stem thermometers (either indicating or recording), by thermo-couples, or by resistance units and a Wheatstone Bridge. Four of the eleven companies reporting used thermo-couples, six used thermometers, and one used a resistance coil and bridge.

Where thermo-couples were used they were in most cases buried directly in the ground, being installed there permanently. In one case the thermo-couple units were placed upon metal blocks and were then buried. Another company fastened the thermo-couple units to a metal block attached to an iron rod, which is driven into the ground. The metal blocks are insulated from the rod by solid rubber. Another company used a long wooden rod with a metal point upon it. Metal bands were placed around the wood rod at intervals. The thermo-couples were attached to these bands. The leads were carried up the rod in a small groove. The wood rod

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[2] R. P. Lutzi, Pacific Gas and Electric Company, chairman. E. R. Stauffacher, Southern California Edison Company, vice-chairman.
Electric Power Equipment Corporation: C. E. Ingalls.
General Cable Corporation: J. E. Crilly, R. G. Harris.
General Electric Company: G. P. Mackenzie, W. C. North.
Glendale Public Service Department: R. C. Smith.
Great Western Power Company: M. N. Clark, W. K. Cullen, G. H. Hagar.
Kerite Ins. Wire & Cable Company: J. P. Robinson.
Los Angeles Bureau of Power & Light: C. H. Jenkins, C. G. Mansfield.
Los Angeles Gas and Electric Corporation: P. F. Melnick, E. R. Northmore, Z. T. Pettit, G. A. Riley.
Okonite Cable Company: T. T. Kennedy.
Ontario Power Company: C. W. Walker.
Pacific Gas and Electric Company: H. H. Buell, P. E. Chapman, R. R. Cowles, G. L. Hill, H. G. Keesling, H. C. Moyer, Paul Suransky.
San Diego Consolidated Gas & Electric Company: K. B. Ayres, D. J. Kelly.
San Joaquin Light & Power Corporation: H. H. Minor.
Southern California Edison Company: C. E. Biggs, W. C. Curl, C. V. Fairchild, N. B. Hinson, J. F. Hodges, E. R. Stauffacher.
Southern Sierras Power Company: A. C. Putnam.
Standard Underground Cable Corporation: Vinton Smith.
Westinghouse Electric & Manufacturing Company, D. C. Harker, C. C. Potts.

* Report prepared for underground systems committee, Engineering section.

provided sufficient heat insulation to insure correctness of the temperature readings. By driving the rod into the ground to a depth marked on it, earth temperatures could be measured at any point.

Where thermometers were used, they were usually of the long stem recording type. In one case the thermometers were inclosed in a wooden case, the upper front part of which was cut out to expose the scale. Another company reported that earth temperatures were measured by lowering a mercury thermometer into an iron pipe driven into the earth. Another company obtained earth temperatures by indicating thermometers installed in a manhole.

The results obtained by such a variety of means of measurement, when coupled with numerous other varying conditions, will not be strictly comparable. It is therefore recommended in future investigations that temperatures be taken by thermo-couples, resistance units or thermometers buried directly in the ground in such a manner that the atmospheric temperature cannot affect the reading, such as will happen if a thermometer is dropped into a tube driven into the ground or manhole temperatures are taken.

Conclusions Arrived At From Tests Conducted In Thirteen Cities—

Earth temperature tests were conducted in Baltimore, Milwaukee, Bloomfield, N. J., Detroit, Clarksburg, W. Va., Chicago, Cincinnati, Kansas City, Mo., New York City, New Orleans, Philadelphia, St. Louis and Washington, D. C.

The report contains a discussion of the tests conducted in each city and in addition thereto charts and tables illustrating the results of the tests are given. Those members interested in the foregoing details should refer to the report itself, as they are not included in this paper.

The conclusions arrived at from these tests are:

1. The earth temperature varies with the depth below the surface, the maximum temperature decreasing and the minimum temperature increasing with the depth below the surface.
2. The temperature at the same depth varies, due to the influence of the soil conditions, adjacent sources of heat and the heat received from solar radiation.
3. The earth temperature at one particular locality seems to repeat itself with reasonable accuracy each year, following a cyclic, almost sinusoidal curve.
4. Earth temperatures used in calculating cable ratings should have sufficient tolerance to account for the variation at various points in the same city.
5. Paving, and a high percentage of moisture in the soil, in most cases increase the maximum summer, and decrease the minimum winter temperature.
6. Below some depth which may be somewhere between 25 and 50 ft. below the surface, the earth temperature has no seasonal variations.
7. For any one locality the variations in earth temperature with depth follow a definite law, although the same relation does not hold for all localities.
8. There is no consistent relation between the mean air and earth temperatures, the difference between the mean monthly air temperature and the earth temperature for each month at any depth varying for each city.
9. The maximum and minimum earth temperatures lag the corresponding air temperatures by a period which increases progressively with the depth, the lag at the surface probably being practically zero.
10. Further study may develop a means of calculating the monthly variation of earth temperature from the monthly mean air temperature. However, by virtue of the fact that the earth temperatures are readily determined, the value of such theoretical means of earth temperature determination is questionable.

The above conclusions indicate that earth temperatures have a decided bearing upon the carrying capacities of cables and that such temperatures must be considered if it is desired to operate cables and their associated equipment at a minimum investment per kilowatt of load.

Conduit and Manhole Temperatures

This report discusses the fundamental principles underlying the determination of cable ratings. It covers such subjects as the methods of calculation of ratings and the constants involved, and gives special charts for facilitating such computations. The subject of duct constants is covered in detail, data from tests made by several companies being included. The use of thermal time constant, a new factor for predetermining temperatures under variable load, is introduced. The importance of sheath currents is emphasized. Detailed records used in conducting temperature surveys and checking cable operation are illustrated. The problems involved in transformer vault ventilation are summarized and interesting data quoted.

The report states that the fundamental theory of heat transfer in a steady state is based upon the same conception as Ohm's law, namely, the flow varies directly as the potential, in this case the temperature difference, and inversely as the thermal resistance. A gradient or temperature drop in the component parts of the heat flow circuit is therefore dependent upon the respective thermal resistance of the component parts. The total thermal resistance is ordinarily considered for theoretical calculations as consisting of three resistances in series, namely, conductor to sheath, sheath to duct wall and duct wall to base earth temperature. The first two can be calculated with reasonable accuracy, but the last quantity is difficult to obtain with any degree of accuracy unless tests are made on each section of duct line under consideration. The last thermal resistance, i.e., duct wall to base earth, is commonly called the heating or duct constant and is fully discussed in this report.

The majority of the companies reporting to the underground committee have chosen the earth temperature as the best ambient. However, one company preferred to use the outside air, maintaining that the heat is not dissipated to the soil, but to the outside air. This assumption is questionable because duct constants calculated from this assumption show wide discrepancies between the calculated constants and those obtained by tests. Moreover, due to the differences between earth and air temperatures, it is felt that the use of the air temperatures as an ambient is not good practice. The report recommends that the earth temperature be used as the ambient, i.e., the reference point from which all subsequent calculations should be made.

The report indicates that the study of duct constants is still incomplete and will require considerable further research. The majority of companies which have reported on this subject have made scattered surveys from which no definite conclusions can be drawn and the results of different companies cannot be compared because of the lack of information on some of the necessary conditions, the small number of tests and the variation in the conditions under which these few tests were made. It is recommended that the national underground systems committee be consulted before making such investigations, so that such conditions as outlined above may be eliminated in the future.

Some interesting conclusions reached by Professor Knipmeyer of Rose Polytechnic Institute from preliminary tests now being conducted are:

1. The heat dissipating ability of the different types of ducts is in the following order: clay, stone and fiber.
2. The burden of heat dissipation is largely upon the duct system instead of upon the surrounding earth. While the surrounding earth may naturally be a poor heat conductor, its larger cross section facilitates heat flow.
3. The duct system should be of a material of the highest heat conductivity because the very small cross section for heat flow within it forces a vastly greater concentration or intensity of flow within its material. Otherwise very great temperature drops are inevitable.
4. Various common duct materials have widely different values of heat conductivity, which fact is of highest importance in considerations of cable heating and capacity.

The Bureau of Power and Light of Los Angeles has made and is now making some detailed studies of duct lines, the re-

sults of which are included in this report. It is of interest to know that the national committee has recommended that the method of procedure as followed in the Bureau's tests be followed for all future studies.

Sheath Currents—

On the subject of sheath currents of those single conductor cables which are used to transfer three-phase energy, the report states that the total loss in the cable is considerably increased by such sheath currents. It has been found that the sheath loss in single conductor cable operating on a three-phase system, when each of the three single-phase cables are installed in separate but adjacent ducts, will vary from 25 to 250 per cent of the loss in the conductors when operating at a frequency of 60 cycles. If three single-conductor cables are installed in one duct, the sheath loss will vary up to 15 per cent of the conductor loss at 60 cycles. The elimination of the sheath losses in single-conductor cable will reduce the conductor temperature from 5 to 40 deg. C. if the load is unchanged. Consequently, the reduction or elimination of sheath losses results in an increase in the permissible cable loading. One company is attempting to reduce its sheath currents by installing cable equipped with joints having insulating sleeves, the lead sleeve being divided transversely into two separate sections by means of an insulating ring. The purpose of this type of sleeve together with a system of special bonding is to prevent the flow of sheath currents between adjacent sections of the cable.

Temperature Surveys—

Only four out of the twenty operating companies which reported to the committee have any routine temperature tests other than surveys conducted for those sections suspected of being overheated. Only twelve of those companies make routine tests of conduit run, the other two companies making routine tests at certain designated manholes. The report states that attention is invited to the fact that frequent checks of duct temperatures and estimates of copper temperatures under various conditions of loading are necessary in order to load fully all of the cables and therefore obtain the maximum utilization of the capital invested in the cable systems. In view of the fact that the investment in underground cable of any operating company in urban districts is an appreciable part of the total system investment, it becomes quite important that care be taken to obtain the maximum use of this investment. The fewer and the less accurate the checks made on operating temperatures of the cable system, the greater will be the margin of safety required between the permissible and the actual operating temperatures, thus entailing a greater cable investment to obtain this margin.

Temperature Survey Records—

A few companies record the results of temperature surveys with the loads of the cables on forms suitable for future reference and study. The committee believes that on an underground system of any extent the expense of following the cable loadings by record is fully justified by the savings in cable investment and the reduction in cable failures due to overloading.

Underground Transformer Vault Ventilation—

Resulting temperatures in transformer vaults due to load within them are dependent on several factors, some of which are within the control of the engineers, namely, type of construction, type of ventilation, efficiency of transformers, etc. On the other hand, the general location of a vault is determined by the size and nature of load to be served, the exact location being determined by street obstructions leaving very little choice to the construction engineer. Here again soil conditions enter into vault temperature conditions.

The radiation of heat from the vault is, to some extent, dependent upon the area of the inclosing walls but mostly upon the type of ventilation used for any given load condition; the operation of transformers within the vault is entirely dependent upon the ventilation provided. When the load losses, in terms of heat, exceed the ability of natural ventilation and wall dissipation, then some means of mechanical ventilation may be used to limit the temperature rise.

In summarizing the answers to the questionnaire distributed on vault ventilation it is evident that there is still much to be learned regarding basic necessity for heat control in transformer vaults and the prolonged effect of overheated vaults on transformers, circuit breaker, cables, etc., installed therein. The committee recommends further study on this subject so that the necessary formula for the calculation of air flow with natural and forced ventilation may be determined.

Replies from the various companies indicate that the net cu.ft. of air space per kva. maximum transformer capacity in transformer vaults is estimated at from 0.6 cu.ft. to 6 cu.ft. per kva. One company, however, gives an estimate of 30 cu.ft. per kva. An average of all answers, not including the above exception, is 3 cu.ft. per kva.

The report states that there is practically no data available for calculating the air flow for natural ventilation. It gives, however, detailed test data submitted by two companies on their standard transformer vaults. These tests covered natural and various types of forced ventilation; however, the committee concluded that due to there not being a sufficient number of tests conducted, no definite final conclusions could be arrived at.

CALCULATION OF CABLE TEMPERATURES IN SUBWAY DUCTS

This report was prepared by W. B. Kirke, outside plant engineer of the Brooklyn Edison Company and was presented at a recent meeting of the underground systems committee.

The report gives a comprehensive survey of the whole problem of cable temperatures by consolidating information on cable temperature characteristics with the equally important problem of ascertaining the characteristics of the duct structure when the cable circuits are subjected to the cyclic loads usually found in practice.

Much of the information covered in the foregoing two reports is repeated. The contents of the report are such that a summary, other than that mentioned above, cannot readily be made. The theory and development of formula, etc., of cable temperature determination are given and fully explained step by step. It will well repay those engineers who are intimately interested in this subject to study the entire report, especially that part dealing with the determination of the temperatures in loaded duct structures, and with the behavior of cables carrying cyclic loads.

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*Application of A.C. Network System**

The first application of low voltage a.c. network was made on the Pacific Coast by the Puget Sound Power and Light Company in 1922, but up until last year this type of installation has not been in use in California. This report concerns itself with a description of the protectors tried out and with the details of the installation made by the Pacific Gas and Electric Company in order to supply service to a number of large office buildings in the downtown district.

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* Report of subcommittee on application of a.c. network, underground systems committee, Engineering Section. P. E. Chapman, chairman. C. V. Fairchild, G. H. Hagar, D. C. Harker, R. G. Harris, C. E. Ingalls, C. H. Jenkins, D. J. Kelly, G. P. Mackenzie, Z. T. Pettit.

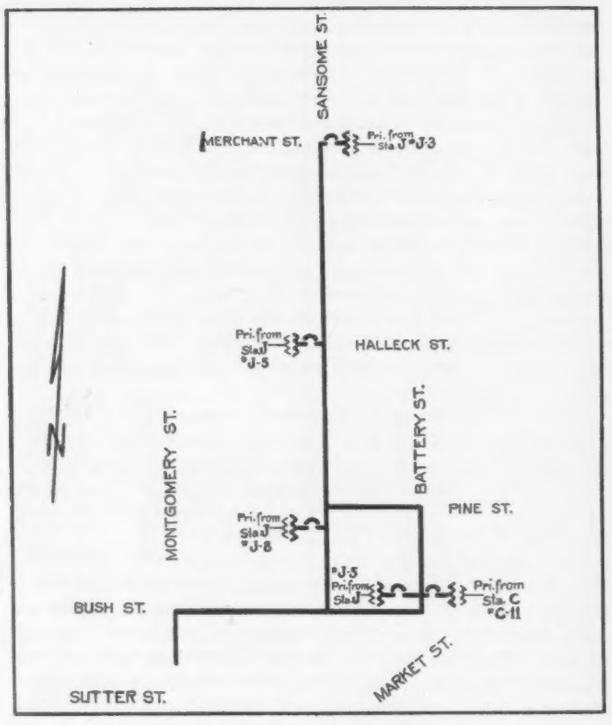

Fig. 1. Existing network in San Francisco.

THE first application of low voltage a.c. network was made by the Puget Sound Power & Light Company of Seattle in 1922. The Pacific Coast therefore was a pioneer in developing the first system of this type of installation. Other utilities on this coast were slow to follow the example of the Puget Sound Power & Light Company. Although many network systems have been inaugurated since 1922 in the Eastern, Southern and Middle sections of the United States, no record can be found of any installation made in California until 1930.

Applications in California

The engineers of the Pacific Gas and Electric Company have been considering the application of the network system in the cities of Oakland and San Francisco for some time. Answers to inquiries sent out to other utilities in California disclose that a number of companies have been making a study of the network system but have as yet no definite facts to report. The application of the a.c. network system therefore is limited to the system installed in San Francisco by the Pacific Gas and Electric Company. The Southern California Edison Company has been making a study of the Long Beach underground system but has reached no decision as to whether the network system will be advisable or not. The Department of Water and Power of the City of Los Angeles has decided to continue the use of automatic transfer switches on the primary transformer banks, feeling that the cost and reliability would be about the equivalent of a network system.

First Installations

The installation of a low voltage a.c. network system in the new Shell Building in San Francisco and in the streets in the vicinity is the first application in California.

Description of Protectors

In the consideration of a network system it was decided to try out protectors made by two manufacturers. A brief description of the protector furnished by the General Electric Company follows:

The network protector itself consists of a motor or solenoid operated air circuit breaker, operated automatically by relays, generally two; a three-element relay to open the breaker on reverse power and act as a voltage directional relay on closing, and a single-element phasing relay which prevents reclosure when the incoming transformer voltage lags the network voltage. This feature prevents pumping of the protectors through voltage displacements caused by induction regulators and cable charging currents.

Fig. 2. Showing first 200-kva. transformer opposite the ninth floor of the Shell Building at Bush and Battery Sts.

The breaker mechanism allows either hand or automatic operation and is arranged to be trip-free in any position. Fuses of high ampere rating are provided as a final protection for the breaker in the event of failure to clear shorts.

The entire mechanism is quite accessible and may be removed while both sides of the protector are hot. The relays are easily removed for inspection or test. The number of wearing parts are reduced to a minimum and such parts as contact tips, fuses, etc., are easily changed.

Protectors may be of either the open or enclosed type, and are supplied in several ratings such as 500, 800, 1,200, 1,600 and 2,000-amp.

A brief description of the Westinghouse type CM-2 automatic network protector is as follows:

The complete protector is mounted on an ebony asbestos panel, the operating mechanism on the left, the three-pole circuit breaker on the right and the master relays and control details on a swinging steel panel in front.

The breaker itself is of the butt contact construction and is equipped with main contacts made of pure silver plate and

arcing tips of copper. Powerful springs behind the moving contacts provide contact pressure. Connections to the breaker are designed so that it may be disconnected from the secondary network and the distribution transformer without removing the cables.

A very simple rugged operating mechanism is used, which was especially designed so that no triggers are in motion during the closing operation. Possible failure to close is thereby reduced to a minimum. The mechanism is mechanically tripped free and motor operated. Tripping is accomplished by means of a shunt trip device which will trip at as low as 15 volts.

The entire operation of the protector is controlled by two relays—one known as the type CN-3, three-phase, master relay and the other as type CNA single-phase, phasing relay. The CN-3 relay has three electro-magnets each equipped with a potential, phasing and current circuit. The phasing coil together with the potential coil control the closing operation of the protector while the current coil, together with the potential coil, controls its opening on reverse current. With the master relay alone, there are possible system conditions which might cause pumping. The CNA relay takes care of these conditions and does not close its contacts unless conditions are such that the three-phase relay will not trip the circuit breaker immediately after the circuit breaker closes. The relays are so mounted that the removal of the terminal screws disconnects them both mechanically and electrically without disturbing any of the wiring. By this same mounting the relays can be disconnected for testing without removing them from the panel.

Fig. 3. Last of three 200-kva. transformers arriving at the 29th floor of the Shell Building.

The entire protector unit is mounted inside a water-tight welded sheet steel housing, the cover of which may be hinged on either side. The cover is clamped to the base against double gaskets by means of "C" clamp bolts. Two windows of non-shatterable glass are provided through which the operation counter, position indicator and the condition of the fuses and circuit breakers can be seen. An external operating hand is provided which may be used to open or close the protector or to lock it in the neutral or open position.

Test Installation

Before placing in use any of the network protectors which are necessary in a low voltage a.c. network system a trial installation was set up in the transformer shop of the Pacific Gas and Electric Company in San Francisco. The picture of this installation and the wiring diagram are given in this report. The protectors were set up in a temporary manner for the purpose of inspection and experimental test to determine the correctness of the claims made for them. There was only one 3-phase delta-connected service available, so two banks of six transformers each were used to break up this service into two separate four-wire Y-connected secondaries. Six 300-watt lamps were used to constitute a network system and load.

The following tests were made:

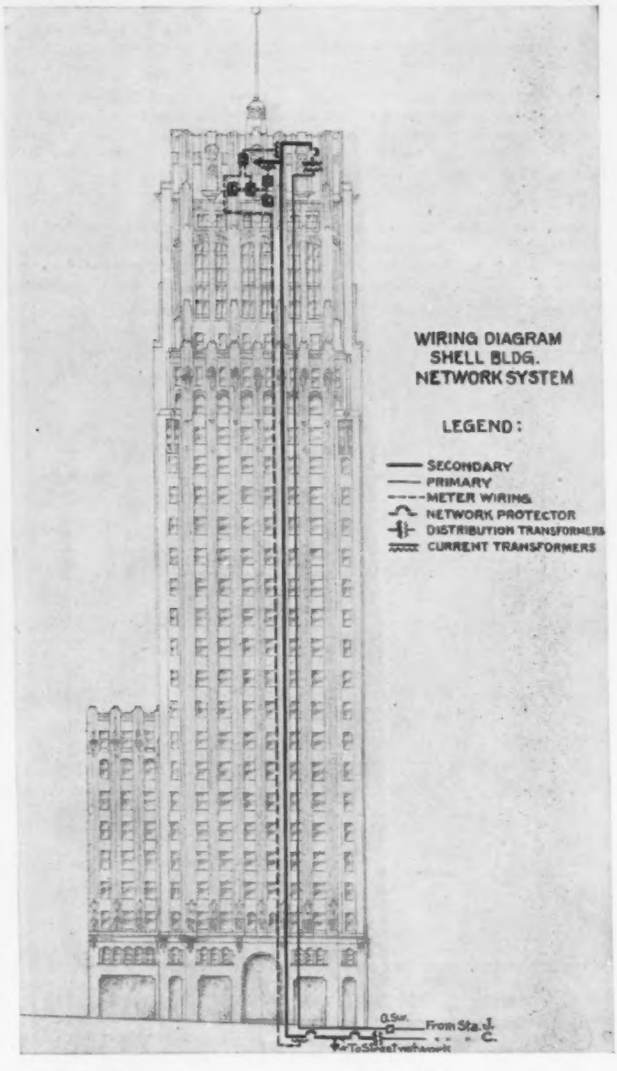

Fig. 4. Wiring diagram of the Shell Building network system.

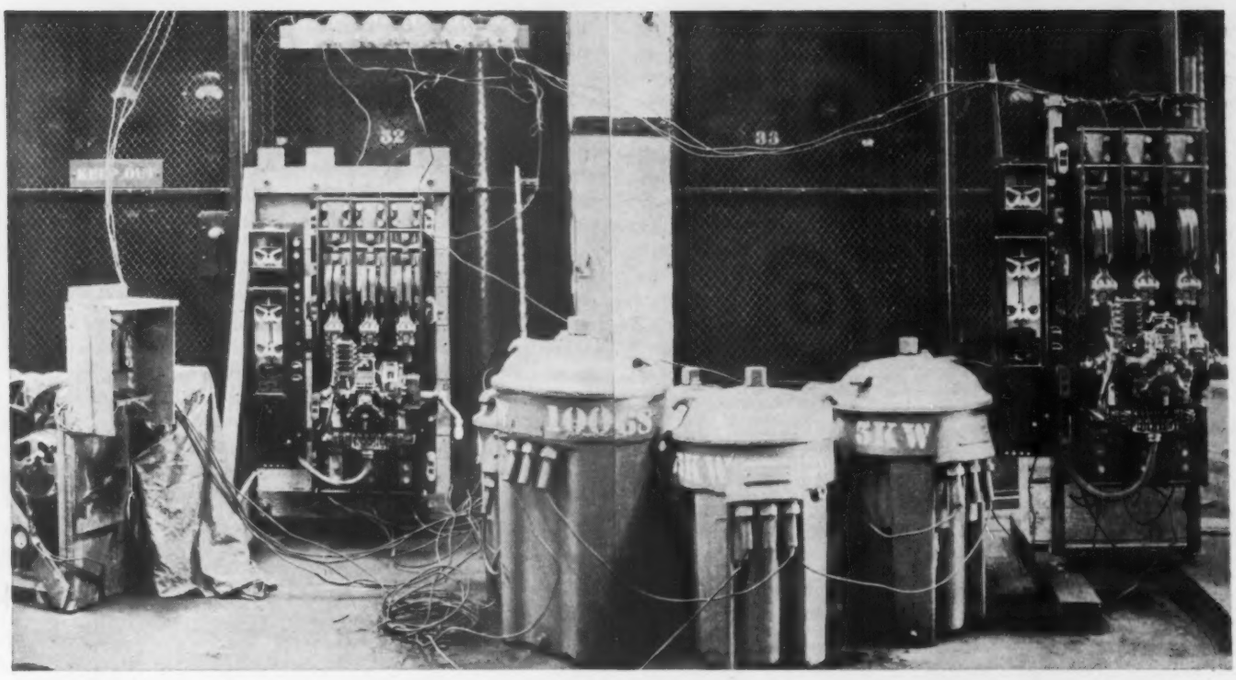

Fig. 5. A network protector set up for test.

Test No. 1.

One of the protectors was put in service and functioned promptly but when potential was applied to the second one, it did not respond due to the potential being the same on both sides of the open protector. This operation was correct, as claimed.

Test No. 2.

Reactors were inserted between the lamps, as shown by the resistance "A." The same order was followed but the second protector failed to close due to phase displacement caused by the reactors holding the phasing relay contacts open. This condition was also correct.

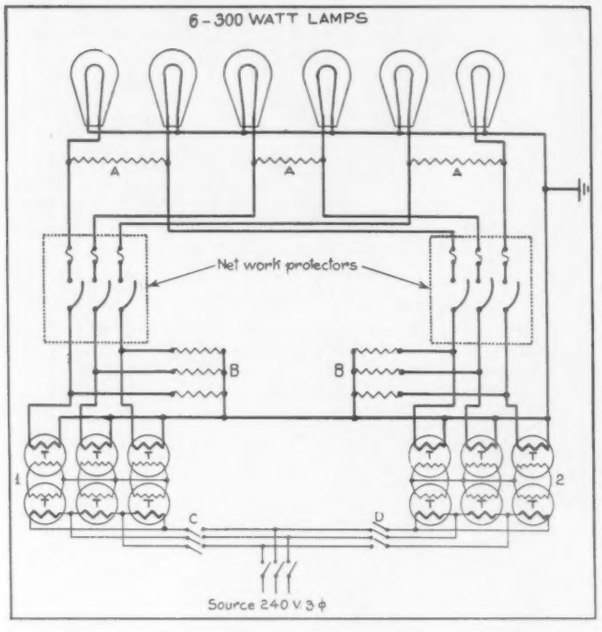

Fig. 6. Connections used for trying out network protector operation. Note: A=Resistance inserted to obtain higher voltage on transformer side of open protector. B=Resistance inserted to obtain sufficient reverse current; transformer execution inadequate. T=Transformer connected to give two separate star banks.

Test No. 3.

Resistors were substituted for reactors and the same test made. Both protectors functioned properly in regular order due to the higher voltage on the transformer side of the open or second protector.

Test No. 4.

Both banks were feeding the network through their respective protectors. Switch "C" was open, the polyphase relay reversed due to reversed current caused by the exciting current of the transformer bank. After a few seconds the protector fed from switch "C" opened. This operation was correct as claimed.

NOTE: Resistors "B" were used to augment the reverse current as the exciting current of the small transformers was insufficient to cause the polyphase relay to reach the opening point.

Test No. 5.

The trip-free arrangement operated successfully when an attempt was made to close the open protector against a dead transformer bank.

Test No. 6.

One of the transformers on one of the banks was reversed. The protector was held open by the action of the polyphase relay and therefore could not have closed when potential was applied to the transformer. This operation was also correct.

All of the claims made for the protectors were found to be correct. However, it would not be advisable to depend too much on the trip-free feature as a safety measure. The operation of the trip-free mechanism is performed by the potential of the network energizing the trip coil. Momentarily the transformers and feeders are energized while the attempt is being made to close the protector by hand. The maximum voltage obtainable during this short period reached approximately 30 per cent for a fraction of a second. However, if the trip coil should burn out or develop an open circuit, it would be possible to close the protector by hand against a dead bank and feeder. This would, of course, energize the transformers and feeders from the network system.

Great care must therefore be exercised in closing the protectors by hand, and this should be done only by authorized persons.

The Shell Building

The new 29-story Shell Oil Building, at the northwest corner of Bush and Battery Sts., presents the first network to go in service in California.

The original request for service called for transformers at the 29th floor to supply the elevator load, with transformers at the street level, or in the basement, to supply the lighting load, together with double throw service on all equipment. Consideration of these points led to the conclusion that the most economical method of supply would be a network system, supplying 120/208 volts three phase for both lighting and power.

Primary supply for this arrangement was laid out from two stations. A new 250,000-circ.mil three-conductor cable was run from an existing feeder from Station "C" to supply the transformers in a manhole in the street in front of the Shell Building. An extension from an existing feeder from Station "J" was made to supply the transformers on the roof; the two connected through the necessary network equipment to a bus work running the entire length of the building. The feeders supply load to the usual radial system and therefore cannot be removed from service without dropping load. It was necessary then to provide for ties to other feeders which would not be advisable in a standard network.

The following arrangement of transformers was made:

Three 200-kva., 2,300/120-volt, low loss type, 3 per cent reactance transformers were installed in a vault on the 29th floor. This 600-kva. bank will probably be larger than necessary to supply the load, but due to the difficulty of installing, it was felt advisable to put in over-capacity, in order to obviate future difficulties when and if the load grew beyond the capacity which could be supplied from a smaller bank.

A transformer manhole was built in the street adjacent to the building and in this vault three 150-kva., 2,300-/120-volt, low loss type, 3 per cent reactance transformers are installed. On the secondary side there is one 2,000-amp. non-submersible type network protector installed in the vault on the 29th floor. In the manhole one 1,600--amp. submersible type network protector is installed. In addition, one 2,000-amp. submersible type network protector was installed in the sub-basement, in order to prevent backfeed through the building to the street. The larger capacity protector, together with the one in the sub-basement, were installed to comply with the demands of the Department of Electricity.

All of the above equipment was installed by the Pacific Gas and Electric Company.

The secondary bus work between the 29th floor vault and the sub-basement, as well as the primary between the same points, was installed by and is the property of the Shell Building.

Primary and secondary conductors within the building have points of interest both from an electrical and a mechanical standpoint. The primary is a four-conductor 2/0 19-strand tinned copper cable with insulation sufficient for 11,000 volts, with which it is proposed ultimately to supply the network system. Each conductor is taped with 0.005 tinned copper tape, and the entire cable armored with No. 10 B.W.G. galvanized wire. The over-all diameter is 3.03 in. The cable is supported from the top only by means of the anchor wires, which are carried over an anchoring pin and brought back upon themselves where they are served. At the top and bottom the cable is brought out of the riser pipe through L-shaped pull cans. On the horizontal runs the cable is unarmored. To comply with the ruling of the Department of Electricity, an oil switch is installed in the sub-basement in order to permit killing the primary feeder to the 29th floor. Oil fuse cutouts are installed on all trans-

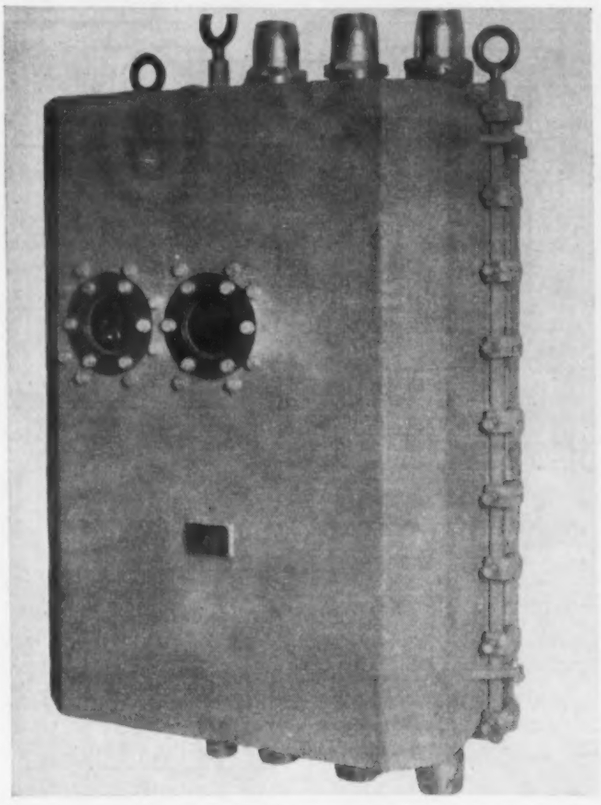

Fig. 7. Westinghouse subway type CM-2 1,600-amp. network protector. The housing door is closed, showing position indicating lamps and operation counter visible through left hand non-shatterable glass window. Protector breaker, protector main and control fuses can be observed through right window.

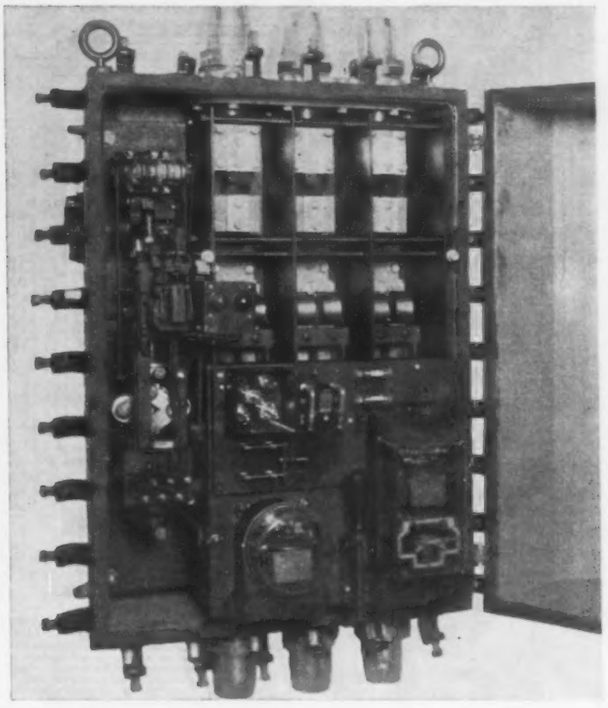

Fig. 8. Westinghouse subway type CM-2 1,600-amp. network protector with housing door open and hinged relay panel closed. Double arcing contacts of the protector breaker can be seen directly above relay panel. Motor operated closing mechanism is mounted separately and to the left of the protector breaker.

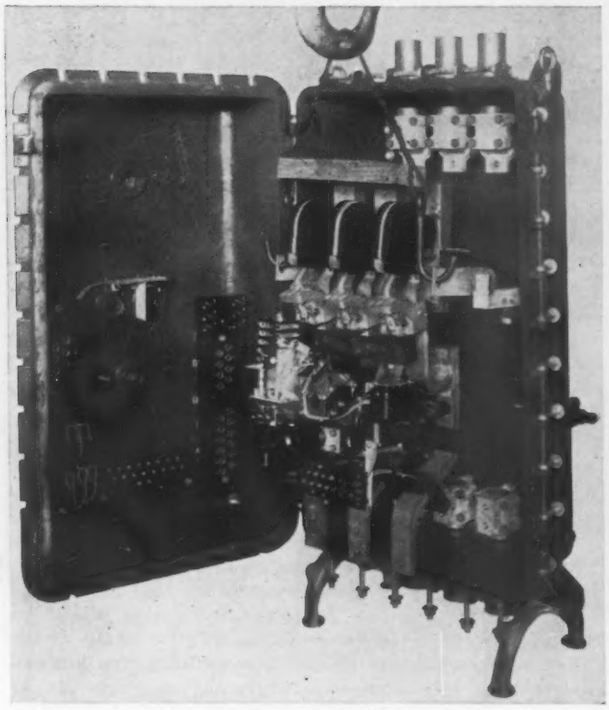

Fig. 9. General Elecric type MG-6 network protector, showing method of removing assembled breaker unit.

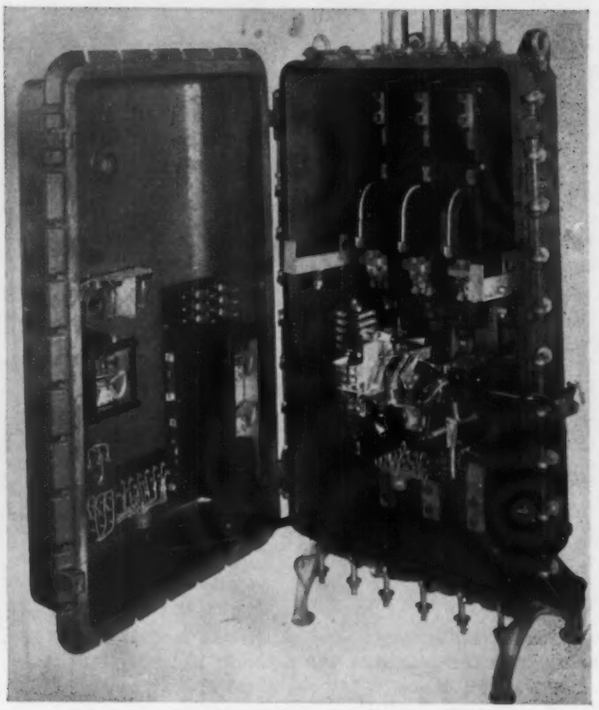

Fig. 10. General Electric type MG-6, 250-volt, 1,200-amp. a.c. network protector with cover open.

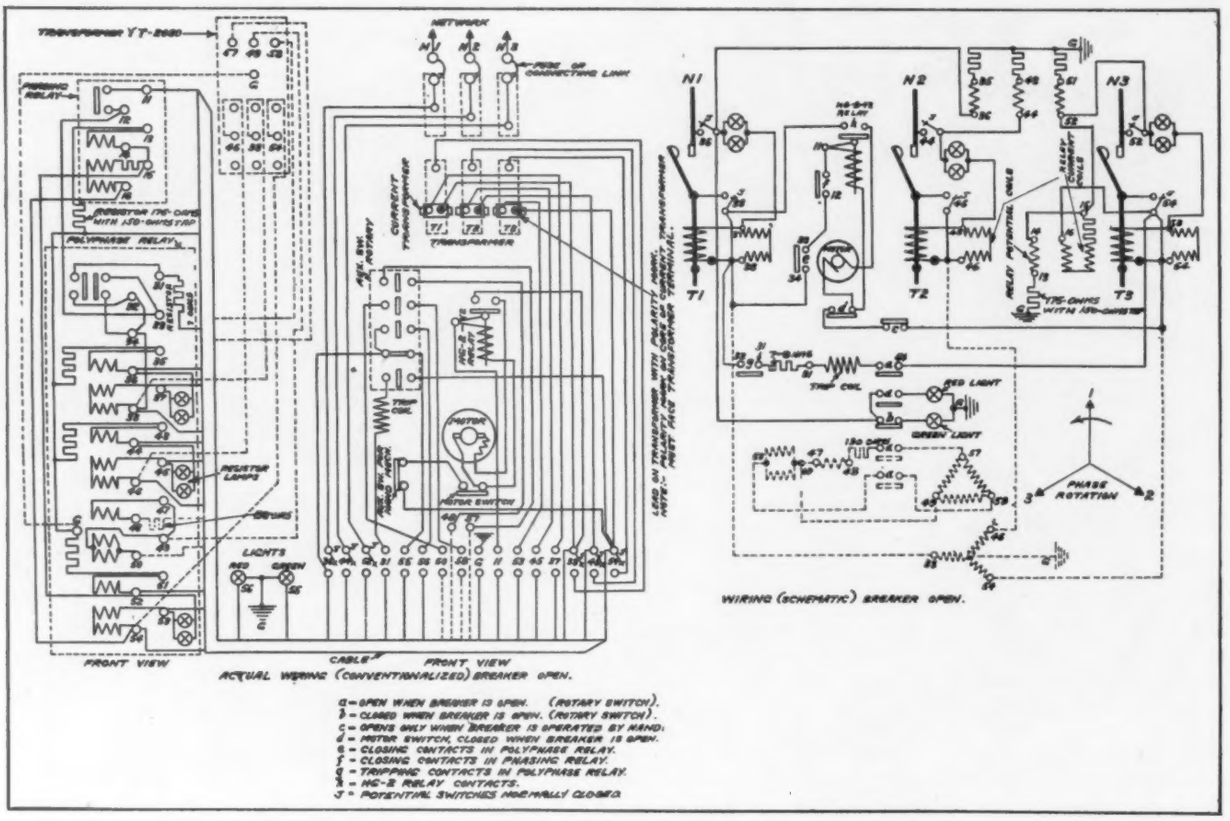
NETWORK
N1
N2
N3
T1
T2
T3
RED LIGHT
GREEN LIGHT
PHASE ROTATION
WIRING (SCHEMATIC) BREAKER OPEN.
FRONT VIEW
CABLE
ACTUAL WIRING (CONVENTIONALIZED) BREAKER OPEN.
a = OPEN WHEN BREAKER IS OPEN. (ROTARY SWITCH).
b = CLOSED WHEN BREAKER IS OPEN. (ROTARY SWITCH).
c = OPENS ONLY WHEN BREAKER IS OPERATED BY HAND.
d = MOTOR SWITCH, CLOSED WHEN BREAKER IS OPEN.
e = CLOSING CONTACTS IN POLYPHASE RELAY.
f = CLOSING CONTACTS IN PHASING RELAY.
g = TRIPPING CONTACTS IN POLYPHASE RELAY.
h = HG-2 RELAY CONTACTS.
j = POTENTIAL SWITCHES NORMALLY CLOSED.

Fig. 11. Wiring diagram, network protectors Type MG-6 and MG-7, General Electric Company.

formers within the building as well as on the oil switch to permit taking the equipment out of service. This protection is needed, due to the feeder being one which supplies other load not connected to the network, thus not allowing the disconnecting of the feeder at the station.

The secondary bus between network protectors consists of four 3-in. (inside diameter) standard pipe size 99-per cent conductivity copper tubes, cut in half, at the fourteenth floor. The upper half of each conductor is hung by means of an insulated bolt passing through a copper cap screwed to the end of the tube. The lower half is supported as a column upon a slab of fiber placed upon a concrete footing. At the middle, in order to permit expansion, the upper tube slides over the lower tube.

Cast copper fittings connected with 18 1/0 flexible cables connect the two sections of each bus. Approximately 6 ft. apart are transite supports, which prevent side sway, but permit movement of the bus, due to temperature changes. Special lugs at each floor connect the bus with panel-boards. The entire bus installation is placed in a vertical shaft, extending the entire depth of the building.

The load is metered by means of current transformers at each end of the bus, connected to a totalizing meter in the meter room on the 29th floor. The elevator load is submetered at this point. By means of a specially constructed relay, the elevator meter demand is automatically subtracted from the demand on the totalizing meter.

The First Street a.c. Network in San Francisco

During the recent years the Pacific Gas and Electric Company has been faced with the problem of supplying service to numerous large buildings in a comparatively small part of the downtown district. The first few of these buildings were furnished service from a transformer bank connected through an automatic primary double throw switch to either of two primary feeders. In case of trouble on that feeder the load would automatically be transferred to the standby primary feeder.

In the early part of 1929, construction work was commenced on the Stock Exchange Building at the southwest corner of Pine and Sansome. The estimated a.c. load for this building was 440 kw. in lighting and 450 hp. in power.

While plans and estimates were being prepared for supplying this building, the Shell Building at the northwest corner of Bush and Battery was started. The estimated a.c. load for this building was 1,134 kw. in lighting and 998 kw. in power.

On account of these buildings being so close together, it was decided to make this load the start of an a.c. four-wire, 120/208-volt Y-network.

After consultation with the building engineers and architects it was decided to supply the Shell Building from a bank of three 150-kva. transformers, connected for four-wire 120/208-volt Y-secondary, located in a vault on Battery St. about 75 ft. north of Bush and from a bank of three 200-kva.

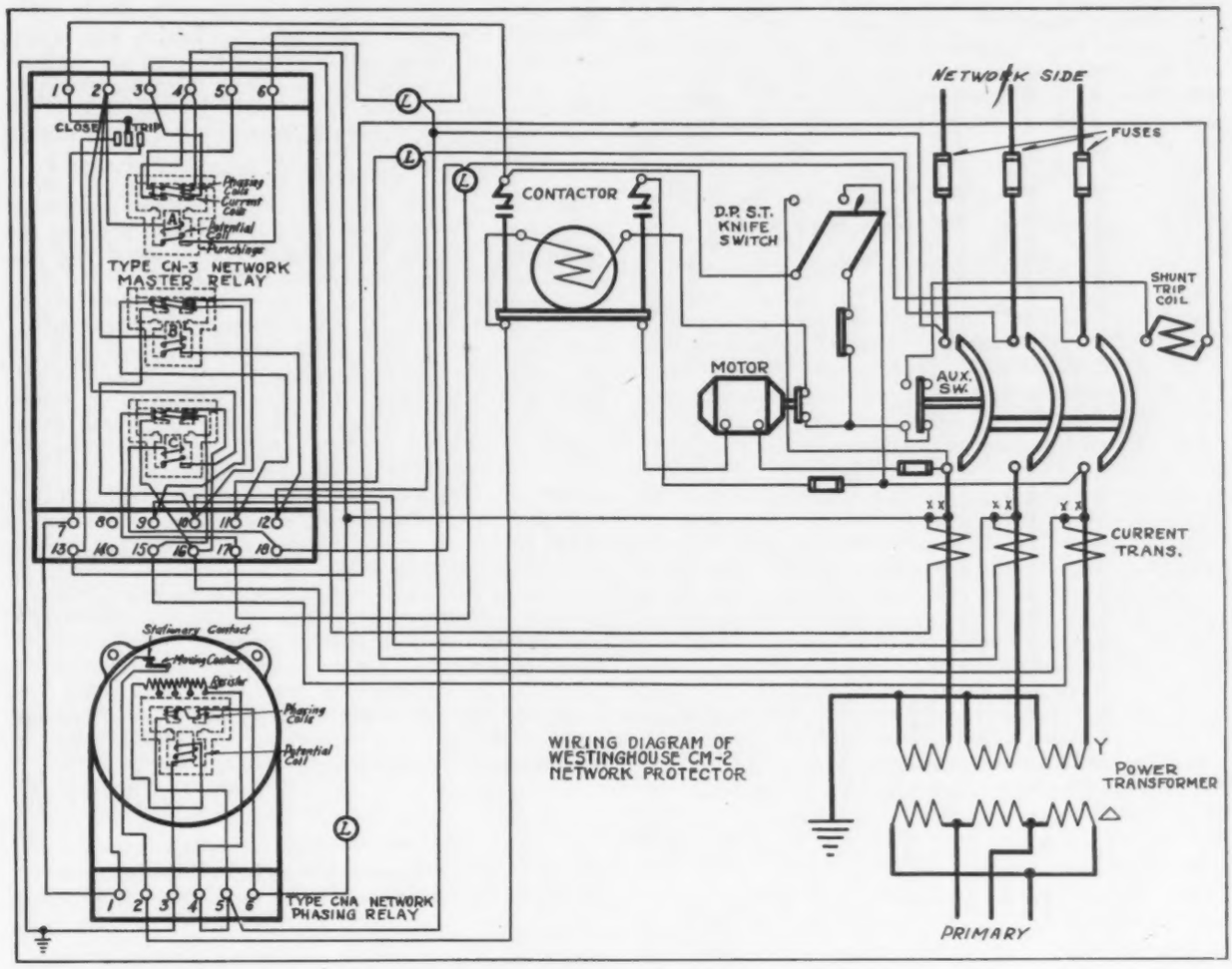

Fig. 12. Wiring diagram of Westinghouse CM-2 network protector.

transformers, located on the 29th floor of this building. To supply these two banks of transformers, it was decided to use primary feeder J-5 feeding from substation "J" located at Commercial and Leidesdorff and primary feeder C-11 feeding from substation "C," located on Jessie east of Fourth St. Both of these feeders were three-phase 4-kv. distribution feeders, with a certain amount of other load on them.

The secondary of the three 150-kva. transformers in the street vault were connected to the street mains through a 1,600-amp. network protector. From the mains two sets of three 500,000-circ.mil simplex cables and two 4/0 weatherproof neutrals were taken into the Shell Building. The bank of three 200-kva. transformers on the 29th floor was connected through a 1,600-amp. network protector to four copper tubes which run from the 29th floor to the basement of the building. To prevent the bank on the roof from feeding current out into the street, a network protector was connected between the copper bus and the service feeding in from the street. This protector was connected up so that it would open up when power was sent out into the street from the building bus.

The Stock Exchange Building is supplied from a bank of three 150-kva. transformers located in sidewalk vault on Sansome about 100 ft. south of Pine. These transformers are energized by primary feeder J-8 feeding from Station 'J". The transformers are connected up for four-wire 120/-208-volt Y-secondary and are connected to the street mains through a 1,600-amp. network protector. From the street mains two sets of three 500,000-circ.mil simplex cables and two 4/0 weatherproof neutrals are taken into the building to supply the a.c. load.

To connect the transformer banks at Bush and Battery with the one at Pine and Sansome three 500,000-circ.mil simplex cables and one 4/0 weatherproof neutral were run around the block bounded by Pine, Bush, Sansome and Battery.

While the above work was being done, remodeling and enlarging of the Crown Zellerbach Building at Sansome and Halleck was commenced. The load in this building was estimated at 75 kw. in lighting and 200 hp. in power. Three 100-kva. transformers supplied from primary feeder J-5 were installed in a street vault at this location and were connected to the street mains through a 1,600-amp. network protector. Three 500,000-circ.mil simplex cables and one 4/0 weatherproof neutral were pulled in on Sansome from Halleck to Pine to connect this bank with the loop feeding the Stock Exchange and the Shell Building.

The Printers Building at Sansome and Merchant has a bank of three 100-kva. transformers supplied from primary feeder J-3 connected Y and it was proposed to tie this bank to the rest of the network. Two sets of three 250,000-circ.mil simplex cables and two 250,000-circ.mil neutrals were pulled in on Sansome between Halleck and Merchant. The reason for using two sets of three 250,000-circ.mil cables instead of three 500,000-circ.mil cables is due to the difficulty which might be encountered burning a fault clear with cable as large as 500,000-circ.mil. It was decided to use bare neutral cable rather than weatherproof in the network, the theory being that the weatherproofing generates considerable gas while in a duct when a fault is being burnt clear.

A later extension of the network to supply the Title Insurance Building on Montgomery, north of Sutter, called for the pulling in for some 600 ft. of three 250,000-circ.mil simplex cables and one 250,000-circ.mil neutral to supply a lighting load of 150 kw. and a power load of 75 hp.

The present transformer banks are protected on the primary side by D&W oil-fused cutouts. This is necessary at the present time because the four primary feeders supplying the five transformer banks feed a number of banks of transformers not in the network.

*Locating Faults in Underground Cables**

Methods of locating faults on underground and submarine cables are briefly discussed in the following report.

FAULTS may be divided into three classes, shorts, opens, and grounds.

The methods of locating faults may be classified under four main headings as follows:

1. Direct inspection and equipment, which we will call the "scan and sniff" method. This is a direct inspection of cables in the manhole.

2. The "cut and try" method which consists of opening the conductor and testing each way with test lamps, voltmeters, or magneto sets.

3. The use of instruments or test sets to determine the theoretical location of the fault. The most common method consists of the use of a Wheatstone bridge by which the resistance is measured from the point of test to the fault and the distance then computed.

4. The use of instruments or test sets which lead the inspector to the fault and say, "There it is." Apparatus available for this work consists of an analyzer for determining the nature of the fault and an interrupter and exploring coil for the actual location of the fault. The method consists first in analyzing the fault and, if of high resistance, breaking it down and carbonizing it by means of current from "step-up" transformers. Once a permanent ground is established, current is fed the conductor through the interrupter. Then, by means of an exploring coil with telephone and head band attached, the inspector is able to follow the course of the cable and determine by the sound in the telephone receiver when he has reached the fault.

Submarine Cables

Submarine cables present a vastly different problem as inspection is impossible without raising or underrunning the cable, which is an expensive and difficult operation and may cause damage to splices and insulation.

A fault in a submarine cable, if of high resistance, is usually broken down by sending over the faulty conductor sufficient current of high enough potential to break down the resistance of the fault and create a good ground. The distance of the fault from the shore can be roughly determined by volt and ampere readings, after which the repair barge is sent to the shore nearer the fault for underrunning the cable. After the cable has been brought over the sheaves on the barge and is underrun, a feeble direct current is sent over the faulty conductor to ground and the drop in potential of the return current is taken on the armor of the cable between the two sheaves by use of the millivolt meter. The direction of the current as indicated on the millivolt meter, due to the difference in potential, will determine whether or not the fault has been reached or passed. This method is described in a previous report which appeared in the Pacific Coast Electrical Association Proceedings, 1926, Page 219, under the caption, "Repairing the Golden Gate Submarine cables." This method is accurate and dependable even when there is no visible indication of a burn on the armor.

Another method, also used with complete success, employs a radio set embodying the principles of the radio compass.

A 10-amp., 220-volt, 500-cycle alternating current is impressed on the cable intermittently by means of an ordinary sign flasher and a portable generator mounted on a trailer.

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* Report of subcommittee on cable faults, underground systems committee, Engineering Section. W. K. Cullen, chairman. C. E. Biggs, P. E. Chapman, C. H. Jenkins, D. J. Kelly, T. T. Kennedy, J. C. McClung, A. C. Putnam, Percy Robinson.

A rectangular loop 2 x 3 ft. is carried on a launch and the tone produced by the field of the cable is amplified by the radio set, thus producing a note in the ear-phones equivalent to middle "C" of the musical scale.

Customarily the launch follows the course of the cable until the fault is reached and stands by over the fault directing the repair barge where to drop the grapnel. Under adverse tide and wind conditions, the fault has never been missed more than 150 ft. and several times it was found on the grapnel when hoisted to the surface. The time required to locate a fault is the time required to sail from the shore to the fault.

The set can also be used to locate the position of cables while in service, the only difference being a hum of lower tone in the receivers. The hum is first picked up at a distance of 500 ft. and increases in intensity as the cable is approached. No difficulty has been encountered in locating faults in 130 ft. of water, the greatest depth in which trouble has thus far been experienced. Under this method no underrunning is necessary except for inspection when the cable has been damaged by a propeller, anchor, or boat keel, and it is unnecessary to burn the cable for the purpose of breaking down the insulation, as the flash which occurs when the cable fails is sufficient to insure a good ground.

The committee recommends that drills be established by the member companies so as to acquaint the men with the various sounds and noises which indicate the various types and locations of trouble. They believe that, with this method of educating the men, the fault finding apparatus would become of greater value and would be more frequently used.

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*Pulling Stress of Cable Through Various Types of Duct, With a Study of Various Types of Duct, Their Merit and Application**

This report is a summary of replies received from members of the underground systems committee relative to the investigation of pulling stress on cable being pulled through the various types of duct and of the investigation of some of the physical characteristics of different duct materials. This report in an abbreviated form was presented at the September, 1929, meeting held in San Francisco. It has since been amended to include information obtained from members and from tests made in Oakland by the Pacific Gas and Electric Company since that date.

THE following compilation of data on the various conditions which affect stress on cable being drawn into duct lines has been arranged under headings indicating the most important factors involved. They are: lubrication, frictional resistance of duct material, clearance in duct, curvature of duct, length of cable, and pulling speed.

There is, however, in addition to these the important factor of duct line construction and alignment which, aside from comparative tests on cable, must in practice have an important effect on stress. The difficulty of securing data on this as an independent factor is obvious.

Lubrication

The most commonly used lubricants are grease, dry powdered soapstone, and a mixture of powdered soapstone and grease. There are also a number of commercial compounds for which their respective manufacturers make high claims. Two of these were made the subject of test in our general comparative test of lubricants.

Of the ordinary lubricants, a mixture of soapstone and grease, according to tests made by an eastern cable manufacturer proved the most effective in both the concrete and the fiber duct in which the tests were made. Of the other two subjected to the test, the powdered soapstone proved the most effective in the concrete duct, whereas in the fiber duct grease was superior.

Tests made by the Pacific Gas and Electric Company in Oakland, in which one or the other of two commercial compounds, that is, common grease and powdered soapstone and grease, were used, were more in the nature of a test of effectiveness of lubrication in combating various physical difficulties. Data incident to the test showed the two compounds to have nearly the same effectiveness as lubricants.

The test was made with 750,000-circ.mil three-conductor 11,000-volt cable weighing 16 lb. per foot pulled into a 4-in. fiber duct. All conditions other than those stated were made as nearly as possible identical. The following result was shown:

Condition of Cable	Tension at 400 Ft.
Without grease or other lubricant	4,000 lb.
Using Glidden Graphite grease	1,200 lb.
Glidden Graphite, through water	2,350 lb.
Glidden long curve in duct line	1,400 lb.

The results of these and other tests showed the pulling stress of greased cable to average about 30 per cent of the ungreased.

Frictional Resistance of Duct Materials

A test made by the Pacific Gas and Electric Company under the following conditions showed results as here reported:

A 325-ft. section of duct line was constructed to contain one soapstone duct, one cement and one sawdust duct, one fiber duct, and one concrete duct. Comparative pulling tension tests were made in each of these ducts with a 325-ft. length of 500,000-circ.mil three-conductor 11,000-volt cable weighing 12 lb. per foot. Glidden Graphite grease was used in all these tests. A Marten-Loomis dynamometer carefully calibrated with the pulling line was used to record tension. Maximum tensions at 325 ft. on each of these were as follows:

Soapstone	875 lb.
Cement and sawdust	1,000 lb.
Fiber	1,300 lb.
Concrete	1,375 lb.

It would seem the particular advantage in the use of material offering lower frictional resistance is that it permits longer duct sections.

An Eastern company reports that in pulling one 350,000-circ.mil three-conductor cable, 2.95 in. in diameter, weighing 11.6 lb. per foot, into a 5-in. monolithic duct, and using powdered soapstone as a lubricant, the stress ranged as follows:

Feet	200	400	600	800	900
Tension in lb.	1,500	2,400	3,500	5,000	5,800

Compare these tests with Pacific Gas and Electric Company tests made in Oakland where a 750,000-circ.mil three-conductor cable, 3.02 in. in diameter, weighing 16 lb. per foot, and lubricated with graphite grease was pulled into a 4-in. fiber duct, showing results as follows:

Feet	100	200	300	400
Tension in lb.	600	700	850	1,200

The advantage, from the standpoint of the frictional resistance of the duct, seems to be considerably in favor of fiber in comparision with monolithic duct.

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* Report of subcommittee on conduit, underground systems committee, Engineering Section. H. C. Moyer, cairman. M. N. Clark, W. C. Curl, R. G. Harris, G. L. Hill, C. H. Jenkins, D. J. Kelly, T. T. Kennedy, G. P. Mackenzie, J. P. Robinson, Vinton Smith.

Comparing fiber with concrete, a Southern company reports results considerably in favor of fiber. One 4-in. fiber and one 4-in. concrete duct, each 110 ft. in length, were subjected to the test. One 4/0, two 500,000-circ.mil lead covered cables, and one 4/0 bare copper wire were pulled into each duct. Results were as follows:

	25 ft.	50 ft.	110 ft.
Concrete	300 lb.	450 lb.	750 lb.
Fiber	150 lb.	250 lb.	470 lb.

Worthy of note was the fact that the increase in tension was, with the fiber, steady, while with the concrete, unsteady.

Clearance in Duct

No absolutely definite rule can be laid down for clearance. It is obvious that in a short, straight, dry duct, offering low frictional resistance, less clearance will be required than will be necessary under other conditions. At times the requirement of economy and expediency will also influence operations.

Conservative practice will, however, ordinarily require that a single cable should be installed in a duct with a diameter at least ½ in. greater than that of the cable. Where more than one cable is installed in a duct the diameter of the duct should be at least ½ in. greater than a circle enclosing all of the cables. A factor to be considered in this connection is the wedging action of several cables in a duct, particularly when they are of large size.

Curvature of Duct

It has been found that with radii of curvature greater than 300 ft. with ample clearance between cable and duct, the effect of curvature on the pulling tension is not very pronounced. With decreasing curvature, however, the effect becomes of considerable importance.

A number of tests, as reported by one company, were made in an attempt to establish some approximate relationship between curvature and tension. The results were obtained with experimental conduit 100 ft. in length. The alignment of the conduits consisted of one straight and one curved section, each 50 ft. long, the curved section having radii varying from 70 ft. to 250 ft. The cable was installed by being fed in at the curved portion of the conduit. The pulling tension in per cent of tension for straight duct was found to be approximately 105 per cent for a radius of 300 ft., 140 per cent for a radius of 140 ft., and 200 per cent for a radius of 100 ft.

In practice, with certain exceptions, it is advisable to arrange pulling operations so that the cable is fed in at the end nearest the sharpest and longest curves. The reason for this is obvious when it is remembered that the tension on the cable as it enters the curve depends on the weight of cable back of this point toward the feeding end.

Length of Cable

The length of section possible is determined largely by the quality of the duct material, and the weight and strength of the cable. The length, in brief, should be limited to that which will not cause an excessive tension on the cable when being pulled into the duct. The stress should not be such as will cause scoring, gouging, deformation, etc., and under no condition should the stress be such as to cause permanent elongation of the copper.

A conservative rule, as suggested by a cable manufacturer, allows a pulling tension of 0.75 times the total weight of cable being pulled.

Length of sections up to 1,000 ft. were reported in which 350,000-circ.mil three-conductor cable 2.95 in. in diameter, weighing 11.6 lb. per foot, was pulled into a 5-in. concrete duct.

Pulling Speed

The permissible pulling speed of cable in a duct will vary under different conditions, duct section, and cable size. Experience seems to show that in a clear straight duct a single cable can best be pulled in at a speed of about 75 ft. per minute. When this speed is exceeded, difficulties arise in feeding the cable and in giving it a visual inspection at the manhole entrance.

Higher pulling speed it would seem should reduce labor cost, but, since a large amount of time is consumed in operations other than pulling, the amount of work that can be done in a day is by no means proportionate.

Tests seem to indicate that speed affects tension only slightly.

In practice, the pulling line over-tension sometimes has the effect of causing a slackening off and lurching forward of the cable, thus increasing the indicated tension. Tests made show this is more pronounced at higher speed.

Various Types of Conduit

A study of some of the physical characteristics of the various types of conduit has been undertaken by the Pacific Gas and Electric Company in Oakland and some interesting results have been obtained. The materials under consideration are: wood, cement mixed with sawdust, steel pipe, multi-square vitrified clay, cement mixed with asbestos, soapstone mixed with cement, fiber, and cement.

Wood

While we have made no direct experiments on wood as a material for conduit, we have gathered considerable data on the subject. We find that because of the ascetic acid which all wood, whether treated or untreated, is known to contain, and because of the detrimental effect of acetic acid upon lead, wood is not a satisfactory material for conduit unless precautions are taken to neutralize the effect of the acid.

Cement Mixed With Sawdust

Only one duct in one section of this material has been used by us and no tests other than a pulling tension test have been made on it. We would assume from our study of wood duct that because of the wood content this material is unsatisfactory for conduit without special precautions.

Steel Pipe

We have used black steel pipe in this vicinity for many years as pole risers, underground service conduit, and in some instances as regular duct line sections where abnormal conditions existed. Other than its excessive cost, it has been found very satisfactory.

Multi-Square Vitrified Clay

The use of this type of duct with the Pacific Gas and Electric Company has been curtailed because of poor separation of cables, especially at the joints. It is highly abrasive to lead sheath, and the pulling stress on heavy cable in the duct is very high.

Cement Mixed With Asbestos

This duct is still under test and a report will be made later.

Cement Mixed With Soapstone and Fire Clay, Known as "Soapstone Duct"

This is a comparitively new product and gives promise of being a very satisfactory material. Chemical and other tests have been made on it in our laboratory and in the field. A chemical test shows it to contain no material detrimental to lead.

Pulling tension tests in this duct show it to have a decided advantage over fiber or concrete in this respect.

A strength test was made on 3-ft. sections laid as a beam across fulcrums 30 in. apart and load applied at the rate of 500 lb. per minute and the load recorded at failure. The sections failed at an average of 700-lb. load when dry, 400-lb. after three weeks submersion, and after twelve weeks recovery of the submerged sections, 600-lb.

A moisture absorption test was made by submerging a dry 3-ft. section for 24 hours. The absorption was found to be 4.9 per cent by weight.

A wearing test was made by pulling a short section of cable weighing 40 lb. back and forth through a section of duct until it had traveled 2,000 ft. at an average speed of 30 ft. per minute. At the completion of this test, the duct was only very slightly worn, and there was very little wear to the cable sheath.

An arc test was made by casting a short section of duct in a concrete envelope and two very heavy copper bars inserted, one from each end. An arc was set up, approximately 4,400 amp. at 460 volts, and held for 30 second in short intervals, after which the envelope was broken at the point where the arc was applied and examination made. It was found that about 12 in. of the duct had been destroyed, and that for a distance of about 6 in. the duct had been burned totally away, and that about ¼ in. of the concrete envelope had been burned away to a sharp slag.

The test seemed to show that the material left from destroyed soapstone was flakes rather than sharp slag as if left from concrete, thus making it less injurious to cable.

Fiber Duct

An arc test similar to the test made on soapstone duct was made on a short section of fiber duct cast in a concrete envelope. Two tests of 2 sec. each were made with a current value of about 3,700 amp. at 460 volts. The duct continued to burn after each test and the duct wall burned through to the concrete envelope for a distance of 10 in. where concrete slag began to form. Recently in one of our fiber duct lines, one cable failed and took the cable in the adjacent duct with it after burning through the fiber and a 1-in. concrete separation.

Considering fiber duct, moisture is undoubtedly injurious to its strength. Three months immersion showed a 48 per cent loss of strength. Some flaking also has been noted in rodding wet fiber duct lines. Fiber has no recovery when wet for a period of time as has concrete and soapstone.

A test was made on fiber duct to determine the effects of excessive heat on a cable lying in a duct to find out the possibility of its sticking to the duct because of the melting or partial melting of the filler. A section of cable was pulled into a cold duct with a maximum of 213-lb. pulling tension. A temperature of 60 deg. C. was maintained for a period of six weeks, then 100 deg. C. was applied for a short time, after which the whole cable was allowed to cool. The starting tension when cold was 1,600 lb.

Cement

Cement duct as we know it in this vicinity (only that manufactured here has been used) has been employed by us in large quantities. Laboratory and field tests have been made on it from time to time with results as follows:

A wear test showed that the duct pores first fill up with lead after which no more wear to the lead is apparent. It would seem that under ordinary conditions the wear is negligible. Pulling tensions are considerably higher than in soapstone or fiber duct.

A strength test was made on this product under the same conditions as that made on the soapstone duct. Results: breaking strain, dry, 975 lb., immersed three weeks, 680 lb., after twelve weeks recovery of immersed section, 900 lb.

An arc test was also made on concrete duct very similar to that made on soapstone and fiber. Four applications of short duration were made in a short section of duct with a current value of aboue 4,400 amp. at 460 volts. It was found that the duct was destroyed for about 10 in., and burned through to the envelope for about 4 in. The material left in the duct and adhering fast to the envelope was very sharp slag which might be injurious to cable being drawn in. A chemical test shows this duct to have no content injurious to lead.

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*The Effect of Sheath and Stray Currents on the Actual Current Reading Taken With Split Core Current Transformers on Large Single Conductor Lead Covered Cable**

As a result of confusion in the past in determining the actual current flowing in a cable when it was measured by means of split core current transformers with a suitable ammeter and when the cable was covered with a lead sheath, it was decided to make an investigation of this subject during the past year. The investigation was divided into two component parts: first, to determine, if possible, the extent of the error when making such measurements and second, to determine what practical means could be devised to overcome this error.

IT IS well known that single-conductor lead covered cables handling alternating currents have currents induced in the lead sheath in addition to stray currents which may be flowing along the sheath in either direction. When an attempt is made to measure the actual current flowing in the copper conductor by means of a split core transformer and an indicating ammeter, the current flowing in the lead sheath will cause the ammeter indication to be correct. If both the conductor current and the sheath current are flowing in the same direction, the reading will be practically the sum of the two currents, and conversely, if the currents are flowing in opposite directions, the reading will be approximately the difference.

One company reports the results of laboratory tests made to determine the relation between current flowing in the conductor and current flowing in the lead sheath under conditions where it was possible to control the two currents both as to magnitude and direction. As the result of these tests it was found that the ammeter indication was very definitely the result under the two readings and that it was possible to obtain a reading more nearly approaching the actual current flowing in the condenser by utilizing some form of shunt around the split core current transformer. To obtain satisfactory results, however, it is apparent that a rather large and clumsy shunt must be used, as the lead sheath is of sufficiently low resistance to permit a considerable portion of the current induced in the sheath to flow through it and accordingly the shunt does not divert as much current as is desirable. It was further found that a reading more nearly approaching the actual current flowing in the conductor could be obtained by interposing a reactor in the form of a continuous iron ring around the cable and adjacent to the split core current transformer and having both the reactor and the split core current transformer shunted out by a heavy shunt. The addition of the reactor caused more current to be diverted around the shunt and consequently the readings taken with the split core current transformer and the ammeter more nearly approached the current flowing in the conductor.

The following table will show the results of tests made under laboratory conditions and will give an indication of the

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* Report of subcommittee on current measurement, underground systems committee, Engineering Section. E. R. Stauffacher, chairman. K. B. Ayres, R. R. Cowles, Wm. K. Cullen, R. G. Harris, C. G. Mansfield, G. P. Mackenzie, G. A. Riley, C. C. Potts.

TABLE I—Tests to determine effect of sheath currents on readings taken with split core transformer and ammeter when attempting to determine current in copper conductors of cable. Single-conductor cable used—30-ft. length—350,000-cir. mil copper—1,500-volt impregnated paper insulation—⅛-in. lead sheath—Date—Jan. 13, 1930.

Test Number	Amperes in Conductor	Amperes in Sheath	Amperes using split core current transformer around cable	Amperes with split core current transformer shunted out	Conditions
1	50	0	49		No shunt used
2	50	Plus 5.3	53	51.5	Shunted with one No. 8 copper conductor
3	50	Plus 15	62	59.5	Same as above
4	50	Plus 15		58.0	Shunted with four No. 8 copper conductors
5	50	Plus 25	71	65.0	Same as above
6	150	Minus 25	125		Current reversed in sheath
7	150	Plus 25	175	164.0	Current in sheath reversed from above
8	200	Minus 50	150	161.0	Current in sheath reversed from above, Reactor next to split core current transformer shunted with copper wires
9	200	Plus 50	250	215	Same as Item 8

magnitude of the currents flowing and the possibilities of simple corrective measures:

From the above table it can be seen that the corrective results obtained under this particular set of conditions is not as satisfactory as would be desirable.

They do indicate, however, that the use of a shunt, or a shunt with an additional reactor, will give an indication as to whether an appreciable amount of sheath current is flowing and may give some clue as to the reason of overheating of a single conductor lead covered cable.

Another phase of this question and one which is fully as important as devising a means of measuring the current flowing in the conductor is to determine what practicable means are available and in use to minimize the amount of current flowing in the lead sheath. One company reports that the use of copper straps between the various cables in a manhole seem to equalize the sheath currents on the various cables to the extent that the heating due to these currents was minimized. Another method which has been successfully used has been to install a heavy copper shunt between the neutral and the two outside leads of a three-wire 110/220-volt system having the heavy copper shunt in good contact with a lead sheath of the three cables and then to measure the current at some point between the power transformer and the shunt. The most effective method, however, is to open the lead sheath and interpose insulating joints so that there will be no possibility of any appreciable amount of current flowing in the lead sheath. Suitable insulating joints are now available for various sizes of cable and the use of them should in no manner invalidate the usefulness of the lead covered cable. Accordingly the question can be summed up as follows:

First, if it is necessary that the current readings taken with a split core current transformer and suitable ammeter be as nearly correct as possible and if the installation is of a permanent nature, the most suitable means of being assured of correct current readings is to utilize an insulated joint in the lead sheath.

Second, if it is the practice to take readings at random throughout an underground system, the use of a heavy shunt together with a suitable iron reactor which may be slipped over the cable inside of the shunt is advisable to obtain readings as nearly correct as practicable when a split core current transformer and ammeter are used.

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*Leaded Versus Non-Leaded Cable**

To arrive at a conclusion on such a subject, it requires the summary of results obtained in the field where leaded or non-leaded cable is used. To prepare this paper, the practices of various utilities have been secured so that as wide a view as possible could be given on the subject. In this discussion, underground is considered only as ducts constructed of fibre, concrete or iron in a conduit system.

FROM information gathered in a general survey of the kind of cable that utility companies are using, it is evident that lead cable is foremost in underground systems, especially where water or even moisture is in continual contact with the cable.

Factor of Economy

Economy is one of the most important questions in the use of leaded and non-leaded cable.

It is true that there are limits where rubber covered or other non-leaded cable can be used satisfactorily with less cost than leaded cable. Leaded cable costs about 25 per cent more than rubber covered wire, which is a large item in the initial cost of installation. Splicing leaded cable exceeds by 25 per cent the splicing of rubber covered. That alone is an important factor in the first cost. The maintenance cost of lead is less than that of rubber covered unless the lead has been abused in its installation or splicing. We are considering rubber covered wire primarily due to its ability to resist moisture and water. Varnished cambric and weatherproof cable cannot be used in underground systems for permanent installations. In all temporary work rubber covered is used for secondaries while varnished cambric is used for primaries because of reduced cost of labor and cable in installation.

The favored uses of leaded cable, judging from the majority of practices seems to be for all underground systems of important loads where the work is permanent and the ducts subject to moisture.

There are several companies having non-leaded submarine cables in service. One company had unfavorable experience with their non-leaded installations, and in the future will use only leaded cable. Another company has not had their non-leaded cable in service long enough to determine whether it will give satisfaction or not.

All companies reported the use of lead primaries, secondaries and high line cables in their underground systems, except where temporary service is needed. Companies whose present lines are non-leaded, change to lead, whenever it is necessary to replace their cable. Services, it was reported, were also of lead with the exception of residential tracts, where all but one company used rubber instead of lead. There are varied opinions as to whether it pays to install lead or non-leaded cable in the underground systems of residential districts, but generally it is found that lead is pulled for the running lines.

Changing From Non-leaded to Lead

Following are several instances where companies have changed from non-leaded to lead: one company reported that

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* Report of subcommittee on leaded versus non-leaded cable, underground systems committee, Engineering Section. Z. T. Pettit, chairman. Wallo W. Bednarz, H. H. Buell, M. N. Clark, R. G. Harris, N. B. Hinson, C. H. Jenkins, D. J. Kelly, T. T. Kennedy, W. C. North, R. C. Smith, Vinton Smith, Wm. G. Stearns.

two-thirds of all its service failures were due to rubber covered wire. The same concern has adopted lead covered for all underground installations whether large or small. Another points out that weatherproof cables are troublesome due to the fact that when the cable has to be removed after several years of service, the insulation leaves the copper, plugging the ducts.

Turning our attention to non-leaded cables, two kinds of rubber covered are available. The code insulation that meets the specifications of the Board of Underwriters has a safe insulation factor for the designed voltage for which it is to be used. The other is the cable with insulation made up of 30 per cent pure rubber. This cable has higher insulating qualities and will stand considerable mechanical abuse and weather conditions. It has been known to be in good electrical condition after 25 years of service, although it will not stand any mechanical wear without damage after this lapse of time.

Solving Cable Loss With Leaded Cable

Another topic of much discussion is the use of rubber covered wire where a block of current is distributed over a large single conductor cable. The heat of the sheath currents in leaded cable lowered the efficiency to such an extent that several companies abandoned using lead cable and resorted to non-leaded. That solved the problem of sheath currents, but when non-leaded cable was subjected to heavy loads, the insulation tended to break down after a time, eventually resulting in trouble. The problem was partially solved in the leaded cable by the insertion of insulated joints throughout the lines. These waterproof and insulating joints can be purchased on the market and when placed in a leaded cable system satisfactorily reduce cable losses.

Acid Soil and Electrolysis

Other problems which confront cable installations are acid conditions of the soil and electrolysis. Most companies have not found it advisable to install non-leaded cable where bad acid conditions are found. If it becomes necessary to do so, acid-proof insulated wire may be used. Electrolysis can be effectively overcome by bonding, draining and insulating.

The conditions and problems confronting cables are ones that must be studied for each particular section where trouble is found. A remedy in one instance may not be effective in another. Every company runs into its own difficulties and solves them as it thinks best.

Summarizing points favorable to each type of cable, first for non-leaded:

1. In extreme cases of electrolysis, non-leaded can be used.
2. Elimination of sheath currents.
3. Initial cost 25 per cent less than that of lead.
4. Splicing cheaper than for lead.
5. Where small ducts are already installed and larger cable must be used.
6. Emergency cases.

For leaded cable:

1. It is a permanent installation.
2. Absolutely waterproof.
3. Maintenance cost is very low.

*Parkway Cable for Rural and Subdivision Distribution**

PARKWAY cable has been used extensively for street lighting with satisfactory results, but the experience with its use for primary and secondary distribution is very limited. A few installations in different parts of the country have been made, but more time will be required before operating results can be compared. Like most all plans, there are certain places where it is to be recommended and others where the conduit-and-manhole construction should be used.

Under some conditions the installation of parkway cable provides a relatively inexpensive, but effective means of eliminating overhead construction as well as the expense of conduit-and-manhole construction. Parkway cable is laid directly in the ground in a trench from 12 to 18 in. deep, except in streets or in crossing railways, where it should be at least 24 in. deep and covered with a wooden or concrete slab. Parkway cable would seem to have more of a place in rural sections that are built up, or in changing from overhead to underground construction, than in new subdivisions.

Requirements in Los Angeles are such that subdividers of tracts to be served underground shall install all conduits, manholes and vaults as well as services to each lot. These are installed before the streets are completed. When the houses are built, the wiremen extend the service pipes to the switchboard and the service wires are installed by the utility. When installed, the utility maintains all services and duct lines and at the present time believes that it is better to have all service pipes terminate in the manhole. Parkway cable is laid in the parkway between the sidewalk and the curb. Other utilities are there also to contend with, such as water, gas and street lighting.

Only one case was reported to the committee where parkway cable has been installed. This was for a 4-kv. line through a rocky and steep forest section near Lake Arrowhead, which proved to be both satisfactory and economical. Other members of the committee report that while they have no installation of parkway cable, the installation of conduit-and-manhole construction, although the initial cost is greater, will be justified in service rendered and more flexible in making changes and repairs. Also, accidental damages will be less.

* Report of subcommittee on parkway cable, underground systems committee, Engineering Section, E. R. Northmore, chairman. K. B. Ayres, W. N. Clark, W. C. Curl, R. G. Harris, H. G. Keesling, T. T. Kennedy, C. G. Mansfield, W. C. North, J. P. Robinson, Vinton Smith, C. W. Walker.

*Standby Service—When It Is Warranted**

This report considers the present practices on the Pacific Coast in regard to providing standby service. In general it is customary to supply such service when feasible only when interruption to service will result in considerable financial loss, lack of public safety or inconvenience to large numbers of people. The usual service offered by the public utility is adequate and exceptional cases are to be considered on their merits.

A SURVEY of the utilities in the Pacific Coast Electrical Association with regard to standby service indicates that it is customary to supply such service, where economically feasible, to certain large customers to whom failure of electric service will result in considerable financial loss, lack of proper public safety, or inconvenience to large numbers of people. This applies particularly to large institutions, such as hospitals, theaters, department stores, hotels, office buildings, electric railways and other industries where a service interruption entails serious loss in output.

There seems to be no demand for or necessity to supply standby service to the ordinary residential or commercial lighting and power customer, as an infrequent, temporary interruption to his electric service results in very little dis-

* Report of subcommittee on standby service, underground systems committee, Engineering Section. C. H. Jenkins, chairman. K. B. Ayres, P. E. Chapman, G. H. Hagar, N. B. Hinson, E. R. Northmore, H. H. Minor, A. C. Putnam.

comfort or financial loss. It is common practice for modern electric systems to have several power sources, parallel transmission lines with oil switch relay protection, double bus substations and properly maintained distribution lines, all of which function to render practically continuous service. The usual service, therefore, seems to be adequate for practically all classes of customers.

Secondary network systems have been installed in densely loaded areas, also transformer vaults equipped with primary automatic transfer switches, connected to secondary mains for serving groups of customers, are in use. These secondary systems result in very dependable service to the customer.

Some of the larger loads are supplied from two feeders, from the same or different substations, with automatic switches for selecting the emergency line and the eliminating of the preferred circuit, in event of failure of the preferred.

Another method is to divide the load between two utilities with each in readiness to serve the whole in event of failure of the other. This method is unsatisfactory to both the utility and the consumer as it requires double utility investment and penalizes the consumer by the amount of the rate differential. This arrangement, moreover, can be obtained only where two electric utilities occupy the same field.

The rapidly growing diversity in the use of electric service makes reliability of service of great importance. This results consistently in the public demanding better and more reliable electric service. This demand is promoted in some degree by the aggressiveness of the new business forces of the utilities, especially where competitive conditions prevail. There is a distinct forward trend in the character of the service rendered by electric utilities to comply with this demand.

In general, the usual service rendered by the utility is manifestly adequate for all except the most extraordinary conditions. The exceptional case should be considered on its merits. In most instances, complete standby service seems unjustifiable, yet a small emergency reserve may be reasonably necessary for convenience and safety.

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*Comparative Advantage of 6.6, 15 and 20 Amperes in Street Lighting Circuits**

The subject of the comparative advantage of 6.6, 15 and 20 amperes in street lighting circuits is one in which considerable financial loss, lack of public safety or inconon which there is very little practical knowledge or experience available, at least in California. It, however, seems an opportune study at this time because of the rapid trend toward larger and larger lighting units, especially in the business areas of cities and along the arterial streets, and more especially in electrolier installations in those sections.

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REPLIES to a questionnaire recently circulated indicate that there are few, if any, actual installations of 15 or 20-amp. series street lighting circuits in California. Because of this fact, the data and information which are presented here are taken almost entirely from a study which was made by R. R. Cowles of the Pacific Gas and Electric Company and from a paper by Henry E. Butler which was published in a recent issue of the *General Electric Review* and the committee is greatly indebted to both of these writers. The latter paper, especially, is a very complete story of the comparison between the two systems, and is well worth reading for those who have the matter in contemplation.

TABLE I—Comparison of Series Street Lighting Lamps

Rated Lumens	Amperes	Watts	Lumens per Watt
600	6.6	43.3	13.9
1,000	6.6	64.1	15.6
2,500	6.6	147.0	17.0
4,000	6.6	226.0	17.7
	20.0	218.6	18.3
6,000	6.6	329.5	18.2
	20.0	317.4	18.9
10,000	20.0	521.0	19.2
15,000	20.0	762.0	19.7
25,000	20.0	1,225.0	20.4

Several pertinent facts involved in a comparison are at once apparent. The use of 20 amp. on the circuit eliminates the individual series transformers required for large lamps on the 6.6-amp. circuit but at the same time increases the line losses materially. This might indicate that 20 amp. would not be economical on long circuits with lamps of the smaller sizes widely spaced. It should be borne in mind, at the same time, that lamps of sizes smaller than 4,000 lumens are available only for 6.6-amp. circuits and that lamps larger than 6,000 lumens are manufactured only for 20 amp. and that both 4,000 and 6,000-lumen lamps are rated at both 6.6 and 20 amp. The 15-amp. circuit is not considered in this study since the 4,000-lumen lamp, formerly the only lamp at this rating, is available at 20 amp.

The study resolves itself largely into a question of economics, allowing at the same time for such items as obsolescence and safety, both of which are rather difficult to evaluate. The former is especially pertinent to the study of street lighting which is continually undergoing changes and for which new equipment is being continually introduced. A consideration of the trend of street lighting toward larger units might readily indicate an installation which may not be entirely justified at the present time. In the words of Mr. Butler:

> Neither the 20-amp. nor the 6.6-amp. circuit with individual lamp transformers can be stated as being superior to the other for all purposes and for all conditions of installation. Each of the systems has certain merits that are not possessed by the other and, in consequence, the choice of systems should be based upon a comparison of their respective merits with regard to each installation under consideration.

The economics of the subject involves at least the two major items, first cost and operating cost. Most utilities have heretofore employed only the 6.6-amp. circuit in an effort at standardization. Generally speaking, this was done before the advent of the larger lamps which are now manufactured only at the higher ratings, and most utilities employ lamps of all sizes on their systems. The style or variety of lamps which must be stocked are no longer a factor in standardization. It is interesting to note that the 20-amp. lamp has a considerably higher lamp efficiency and a longer life than the 6.6-amp. lamp and also that it is more rugged.

Cost of Installation

The first cost of the 6.6-amp. circuit supplying lamps of 6,000 lumens and larger is very materially greater than is the cost of a 20-amp. circuit supplying the same size lamps. The former installation, of course, introduces an additional transformation which means, in many cases, an additional capacity in series transformers practically equal to the capacity of the constant-current transformer supplying the circuit. This greater cost is at once evident when consider-

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* Report of subcommittee on street lighting circuits, underground systems committee, Engineering Section. H. H. Buell, chairman. K. B. Ayres, Wm. K. Cullen, D. C. Harker, J. F. Hodges, C. G. Mansfield, G. P. Mackenzie, H. H. Minor, A. C. Putnam, G. H. Riley.

TABLE II—Comparison of 6.6 and 20-Amp. Series Circuits

Item	Straight Series		With Individual or Auto-Transformer		With Series Transformers		Two Regulators: Each of Half Capacity on Two Circuits	
			6.6/20 Amp.		6.6/6.6/20 Amp.		6.6/20 Amp.	
	6.6 Amp.	20 Amp.	W/indv.	W/auto	W/indv.	Straight Series	W/indv.	20 Amp. Straight Series
20 kva.								
No. of 600 cp. lamps	59	52	58	57	56	50	58	52
Circuit Ft.	23,600	20,800	23,200	22,800	11,200	10,000	23,200	20,800
Secondary Ft.	....	....	....	....	22,400	20,000	....	....
Lamp Input	19,460	16,504	18,408	18,082	17,774	15,870	18,082	16,504
Regulator Input	20,786	20,748	20,656	20,649	20,753	20,831	20,430	20,848
Efficiency	93.6	79.5	89.6	87.5	85.6	76.5	88.7	79.2
Losses:								
Regulator	900	800	900	900	900	900	1,000	900
Series Tr.	....	....	....	....	560	560	....	....
Indv. Tr.	....	....	928	....	896	....	928	....
Auto-Tr.	....	....	....	1,254	....	....	....	....
Circuit	426	3,444	420	413	203	181	420	3,444
Secondary	....	....	....	....	420	3,320	....	....
Total Loss	1,326	4,244	2,248	2,567	2,979	4,961	2,348	4,344
ω0 kva.								
No. of 600 cp. lamps	89	78	87	86	84	75	88	78
Circuit Ft.	35,600	31,200	34,800	34,400	11,200	10,000	35,200	31,200
Secondary Ft.	....	....	....	....	33,600	30,000	....	....
Lamp Input	29,345	24,757	27,614	27,296	26,662	23,705	27,931	24,757
Regulator Input	31,190	30,931	30,836	31,010	30,854	30,906	31,324	31,149
Efficency	94.1	80.2	89.6	88.0	86.2	76.8	89.2	79.3
Losses:								
Regulator	1,200	1,012	1,200	1,200	1,200	1,200	1,350	1,230
Series Tr.	....	....	....	....	840	840	....	....
Indv. Tr.	....	....	1,392	....	1,344	....	1,408	....
Auto-Tr.	....	....	....	1,892	....	....	....	....
Circuit	645	5,162	630	622	202	181	635	5,162
Secondary	....	....	....	....	606	4,980	....	....
Total Loss	1,845	6,174	3,222	3,714	4,192	7,201	3,393	6,392

Efficiency is the ratio between the input into the lamps and the input into the primary of the regulating transformer.

ing an actual installation. It was found, for instance, in one case that the cost, exclusive of labor, of all transformation facilities per 6,000-lumen lamp would be $8.83 for the 20-amp. circuit and $27.50 for the 6.6-amp. circuit employing individual series transformers. There are several different combinations of circuits which might be so compared, as for instance: those employing auto-transformers; those having two or more lesser capacity circuits fed through SL transformers from the constant-current transformers; those supplied from constant-current transformers of different sizes. Any of these combinations would affect the unit costs but would indicate a very decided advantage in favor of the 20-amp. circuit.

Operating Costs

A comparison of the operating costs of the two systems is rather interesting. In the case for which the above figures are given, it was found that the efficiency of the 20-amp. circuit was 79.5 per cent, while that of the 6.6-amp. circuit supplying the same lamps through series transformers was 89.6 per cent, a very material factor in favor of the latter system. While the 6.6-amp. circuit introduces an additional transformation with its losses, the line losses in the 20-amp. circuit are far higher, with the result that the net losses with the 20-amp. circuit are of the order of twice those of the 6.6-amp. circuit. Inductance losses are responsible for a very large part of the increase. When the conductor is lead covered and is either steel armored, or laid in iron pipe, the net losses with the 20-amp. circuit may be as much as four times those of the 6.6-amp. circuit.

The relative voltages at which the two systems operate is a considerable factor in the problem. With the 6.6-amp. circuit and constant-current transformers of reasonable size, such as 20 kw. and 30 kw., the circuit voltage is relatively high so that the series transformers at each unit serve the dual purpose of transforming to 20 amp. for the lamp and

TABLE III—Comparison of Cost and Efficiency of 6.6 and 20-Amp. Series Circuits.

System	With 20 kva. Regulating Transformer		With 30-kva. Regulating Transformer	
	Cost of all transformation facilities per 600-c.p. lamp	Efficiency per cent	Cost of all transformation facilities per 600-c.p. lamp	Efficiency per cent
Straight Series				
6.6 Amp.	$ 7.78	93.6	$ 6.47	94.1
20 Amp.	8.83	79.5	7.37	80.2
6.6/20 Amp., With Indv. Trans.	27.50	89.6	26.15	89.6
Groups 6.6/6.6/20 Amp. With Indv. Trans.	30.40	85.6	30.80	86.2
6.6/20 Amp.	14.64	76.5	13.12	76.8
Two Half Capacity Circuits With Indv. Trans.	31.70	88.7	28.90	89.2
20 Amp.	13.58	79.2	10.45	79.3

Efficiency is the ratio between the input into the lamps and the input into the primary of the regulating transformer.

also insulating the standard from the circuit, largely eliminating the electrical hazard in case the standard is broken off, and also permitting the safe replacement of lamps and glassware. On the other hand, the 20-amp. circuit carries the circuit voltage to the top of the standard; in spite of the lower voltage of the circuit, it is still classed as a primary circuit and, therefore, introduces a hazard.

For the same transformer capacity the 20-amp. circuit operates at only one-third the voltage of the 6.6-amp. circuit so that cable at a considerably lower voltage rating, and, therefore, cheaper cable may be installed on the former circuit. In addition, because of the elimination of the individual series transformers with their inductance, the 20-amp. circuit has greater lamp capacity but this is offset by the considerably greater line inductance of this circuit.

There are a few additional details which might be mentioned. The 6.6-amp. circuit with individual series transformers operates without film cutouts so that lamp outages cannot affect the remainder of the circuit, whereas the contrary may be true with the 20-amp. circuits, though the standard socket and film cutouts are now operating satisfactorily on such circuits in a number of installations in the East. The manufacturer advises that, for a given capacity, the constant-current transformers have the same price for either 6.6-amp. or 20-amp. secondary current. Most utilities can find places on their systems for 6.6-amp. transformers which are displaced by larger capacity transformers required for installations which are changed to larger size lamps and which may readily operate at 20 amp. if found desirable.

The following summary gives, briefly, the relative advantages of the 20-amp. circuit as compared with the 6.6-amp. circuit supplying the lighting units through individual series transformers:

TABLE IV—Characteristics of Series Street Lighting Transformers

Size Nominal Kilowatts	6.6 Amperes				20 Amperes			
	Secondary Emf. Closed Circuit Volts	Open Circ. Volts	Efficiency at Full Load Percent	Primary PF. at Full Load Percent	Secondary Emf. Closed Circuit Volts	Open Circuit Volts	Efficiency at Full Load Percent	Primary PF. at Full Load Percent
5.0	757	1050	94.0	80	250	345	94.0	80
7.5	1137	1560	94.5	80	375	575	94.5	80
10.0	1515	2080	95.0	80	500	690	95.5	80
15.0	2272	3090	95.5	80	750	1050	95.9	80
20.0	3030	4115	95.5	80	1000	1400	96.0	80
30.0	4545	6130	96.0	80	1500	2090	96.6	80

TABLE V—Line Losses per 1000 ft. of No. 6 Armored Cable by Tests in which both Lead Sheath and Steel-Tape Armor were Short Circuited. (Approximate only.)

(Data taken from the Electrical World, Nov. 18th, 1916.)

Losses in Watts at 60 cycles	6.6-Amp. Circuit	20-Amp. Circuit
$I^2 R$ Loss in Conductor	20	160
Inductance loss—Circuit conductors touching	30	210
Inductance loss—Conductors 1 ft. apart	30	230
Inductance loss—Conductors 4 ft. apart	40	260
Inductance loss—Conductor around room	40	330

The 20-Amp. Circuit—

1. Operates at one-third the voltage of the 6.6-amp. circuit of the same kw. capacity, resulting in less expensive, lower voltage cable.
2. Eliminates the double transformation, thus reducing the investment and simplifying the system.
3. Reduces the likelihood of inductive and radio interference due to the elimination of series transformers, offset to some extent by the possibility of interference because of the type of socket and cutout required, which is in turn offset by the possibility of poor joints in the series transformer connection.
4. Improves the power factor of the circuit.

The 6-6 Amp. Circuit With Individual Series Transformers—

1. Low voltage only is installed in the standard, largely eliminating the electrical hazard.
2. Considerably lower losses in the circuit.
3. Eliminates the use of film cutouts—large outages cannot affect the remainder of the circuit.
4. Reduces the effect of surges on the lamp.

The accompanying excerpts from charts contained in the two reports above referred to may prove of value in the consideration of the relative merits of the two types of systems. The figures contained in these tables are approximate only and should not be used as a basis for exact computation. However, they are sufficiently accurate to serve as a means for comparison.

*Result of Leaving Subway Equipment Submerged Indefinitely**

Submerging of subway equipment for indefinite periods occurs only between periods of routine inspection and is usually avoided. Trouble is sometimes caused where the usual installation is made with lead-covered primary and secondary mains, overhead type transformers, with primary potheaded and taped to open cambric bus, although new transformers of the overhead type have been known to operate several days entirely submerged. Rubber-covered house laterals taped to lead-covered secondary mains with taped joints are apt to cause trouble when submerged.

FROM the reports received from several Pacific Coast companies, it is apparent that the indefinite submerging of subway equipment is in most cases avoided and occurs only between periods of routine inspection. The duration of submerging may be from several hours in the downtown districts to several weeks in the outlying districts.

Effect on equipment depends a great deal upon the equipment itself. Where an all-lead installation is made and strictly subway-type transformers, boxes, and cutouts are used, lids and covers being securely sealed, the only apparent effect is the natural corrosion of the iron or steel cases of the equipment.

Corrosion varies according to the condition of the water, but in most cases the damage is slight and the process is slow. Apparently the corrosive effect is greater and more rapid where there is a partial submerging for any length of time. Transformers standing in 3 or 4 in. of dirty water for several months, when removed, show the bottom of the case badly corroded or rusted due no doubt to condition of water and probable electrolytic action.

In subdivisions where the usual installation is made with lead covered primary and secondary mains, overhead type transformers, with primary potheaded and taped to open cambric bus, a total submerging usually causes trouble to primary feeders and transformers, although new overhead type transformers have been known to operate several days entirely submerged.

When rubber-covered house laterals are taped to lead-covered secondary mains with taped joints or through ordinary low voltage cutout boxes, a great deal of trouble arises from submerging.

* Reort of subcommittee on submerged subway equipment, underground systems committee, Engineering Section. C. E. Biggs, chairman. W. K. Cullem, H. G. Keesling, D. J. Kelly, C. G. Mansfield, P. F. Melnick.

*The Use of I. L. Transformers Versus Compensator Units**

The rapidly growing use of incandescent lamps of large size for street lighting, together with the fact that such lamps operate more efficiently at higher current values than at the commonly used 6.6 amperes, has raised the question of the best method of supplying the higher current to these lamps. Three methods are available. The current in the circuit may be increased to the

* Report of subcommittee on transformers and compensators, underground systems committee, Engineering Section. C. G. Mansfield, chairman. K. B. Ayres, Wm. K. Cullen, G. P. Mackenzie, H. H. Minor, C. C. Potts, A. C. Putnam, G. A. Riley, R. C. Smith, E. R. Stauffacher, Paul Suransky, C. W. Walker.

desired value, or the line current may be kept at 6.6 amperes and stepped up to the higher value at the lamp, using either a small series transformer commonly known as the "I.L." transformer, or safety coil, or a small auto-transformer, usually known as a compensator unit. It is the purpose of this paper to outline briefly the relative merits of the two types of transforming units to be used at the lamps.

REPLIES have been received from two manufacturers and five of the ten Pacific Coast operating companies to which requests for information regarding practice and experience in the use of these units were sent. None of these seems to have made any comprehensive analysis, either of the conditions which determine the type of unit to be used, or of their experience with them. The comments which have been received indicate that cost and objection to the presence of high voltage cables in the lamp post are the primary considerations in the choice of transforming units. In some communities, the extension of high voltage cables above the pavement level is prohibited by ordinance. This restriction necessitates the use of the insulating transformer, and the engineering and economic factors do not enter the problem. The cost will usually favor the use of the compensator unit, particularly since its efficiency and power factor are slightly higher than those of the corresponding I.L. transformer.

The direct cost of the I.L transformer is approximately three times that of the compensator unit. A part of this difference is, however, balanced by the extra cost of the disconnecting pothead, if used, and of the additional high voltage cable required to reach the compensator. With some types of standards, this cost is further increased by the necessity of providing a special casting to obtain sufficient space at the top to mount the compensator unit. But when all of these factors have been taken into consideration, it appears that the total installed cost with the I.L transformer will be substantially greater than with the compensator unit. The relation between this extra cost and the importance attached to the elimination of high voltage conductors from the standard, will very largely determine which unit is to be used.

The presence of high voltage conductors in the upper part of the standard may affect both the reliability and the safety of the installation. While no directly comparable data on failures in the two types of installations are available, it may be said that the probability of failure is somewhat greater with compensators than with the I.L transformers, because of their exposed winding and high voltage terminals. If the compensator is well made, however, and reasonable clearances are provided in the mounting, trouble from this source should be rare. The question of safety is probably the more important one. The City of Los Angeles has more than 45,000 lamp posts containing high voltage conductors in service. While these posts are involved in accidents at the rate of approximately one per day, no case has yet occurred in which any personal or property damage has resulted from the presence of the high voltage conductors. This experience would seem to indicate that the danger from this source is much less than is commonly assumed.

One of the minor advantages of the use of the I.L transformer is the fact that lamp replacements may be made while the circuit is alive, since the open circuit voltage of the secondary is quite low.

The question of interference with telephone and radio reception when the secondary of an I.L. transformer or compensator is open circuited by lamp failure is frequently mentioned as one requiring some attention. No cases of such interference are known to have occurred, however, possibly because of the rather effective shielding of the underground conductors, particularly where metal standards are used. It is probable that any such effect which does occur would be very similar in the two types of units, and it would not, therefore, appreciably affect the choice between them.

Public Relations Section[1]

WOMEN'S COMMITTEE REPORT[2]

THE women of the Pacific Coast Geographic Division are well organized into fourteen separate committees, and their activities cover the work of ten utilities and one manufacturing unit under the capable leadership of the following:

Miss Alma Freeburg—Coast Counties Gas & Electric Company, Santa Cruz.

Mrs. Alice Axtell—Los Angeles Gas and Electric Corporation, Los Angeles.

Mrs. Jeanette I. Rees—Southern California Edison Company, Los Angeles. (*a*) Mrs. Mabel E. Oliver—Southern California Edison Company, Redondo Beach. (*b*) Mrs. Amy Bidwell—Southern California Edison Company, Ontario.

Miss Nell Molloy—San Diego Consolidated Gas & Electric Company, San Diego.

Miss Marie Houlahan—Great Western Power Company, San Francisco.

Miss Clyda Weems—San Joaquin Light & Power Corporation, Midland Counties Public Service Corporation, Fresno.

Miss Miriam Jackson—Hawaiian Electric Company, Honolulu.

Mrs. Jean Roberts, State Chairman—Tucson Gas, Electric Light & Power Company, Tucson. (*a*) Miss Wilma Jones—Arizona Edison Company, Bisbee. (*b*) Miss Louise Scott—Arizona Edison Company, Douglas.

Mrs. Ralph Hitchcock—Pacific Gas and Electric Company (formerly Coast Valleys Gas & Electric Corporation), Salinas.

Mrs. Mercedes M. Gaffney—Graybar Electric Company, Los Angeles.

All of the committees hold at least one meeting a month and some of them hold two, besides taking active parts in the various club, church and civic affairs in their communities. They are all specializing in the study of electricity in the home, not only learning to operate the appliances and to demonstrate their many uses, but also the cost of operation. Each committee has its own method of study, but there is a great similarity in them all. They have, but with few exceptions, divided their appliance study in such a way that

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[1] Executive Committee: Paul M. Downing, Pacific Gas and Electric Company, chairman. E. B. Criddle, Southern Sierras Power Company, vice-chairman.
General Electric Company: M. H. Schnapp.
Los Angeles Gas and Electric Corporation: F. E. Seaver.
Pacific Gas and Electric Company: A. F. Hockenbeamer, A. H. Markwart.
San Joaquin Light & Power Corporation: Mrs. Nyra G. Letchworth.
Southern California Edison Company: S. C. Haver, Jr.

[2] Mrs. Nyra G. Letchworth, San Joaquin Light & Power Corporation, chairman.
Coast Counties Gas & Electric Company: Mrs. Bertha Briggs.
"Electrical Merchandising": Miss Clotilde Grunsky.
Graybar Electric Company: Mrs. Mercedes Gaffney.
Los Angeles Gas and Electrical Corporation: Mrs. Undine Russell.
"Electrical West": Mrs. Dorothy D. Peede.
Pacific Coast Electrical Association: Miss Cristel Hastings.
San Diego Consolidated Gas & Electric Company: Miss Nell W. Molloy.
San Joaquin Light & Power Corporation: Miss Clyda E. Weems.
Southern California Edison Company: Mrs. Jeanette I. Rees.
Tucson Gas, Electric Light & Power Company: Mrs. Jean D. Roberts.
Valley Electrical Supply Company: Mrs. Mabel E. Tripp.

if the girls attend all the meetings until June they will have made a complete study of all the appliances and labor-saving devices, besides carrying on other educational work.

Special mention of the work of our member across the Pacific should be given. Miss Jackson has a splendid program.

Mrs. Rees of the Southern California Edison Company is to be congratulated on the excellent work which her committee has been doing. There are two divisions besides Los Angeles under capable leaders carrying out the work of the

Women's committee members who met at Fresno, Calif., in March during the two-day conference of the Commercial Section, P.C.E.A. Left to right, standing: Mrs. Marian Lorain, Great Western Power Company; Mrs. Jeannette I. Rees, Southern California Edison Company; Mrs. Alice Axtell, Los Angeles Gas and Electric Corporation; Mrs. Nell Molloy, San Diego Consolidated Gas & Electric Company; Miss Alma Freeburg, Coast Counties Gas & Electric Company, Santa Cruz; Miss Marie Houlahan, Great Western Power Company. Seated: Miss Clyda Weems, Mrs. Mabel E. Tripp, both of the San Joaquin Light & Power Corporation; Mrs. Nyra G. Letchworth, chairman, Women's Committee, P.C.E.A., San Joaquin Light & Power Corporation; and Mrs. Ruth E. Creveling, vice-chairman, Women's Committee, N.E.L.A., San Diego Consolidated Gas & Electric Company.

committee. Their annual Doll Contest was a wonderful success. The girls dressed 96 dolls at the Christmas season which were given to the company's welfare secretary for distribution among the needy, a lovely way to express the spirit of Christmas. Also one of these girls, Mrs. Mabel MacFerran, a graduate electrical engineer, has received public recognition. She gave them a real "treat," explaining with lantern slides the electrical development back of the little button on the wall.

Other committees make the Christmas season the time of spreading their cheer to the needy and afflicted by sending food, clothing, even money, as well as taking the time to make personal calls upon them. Neither time nor space will permit me to mention the wonderful work of each committee, but they are all noble, conscientious workers for the good cause. One of the most enthusiastic committees is the newest one, the Great Western Power Company of San Francisco. They are to be congratulated as they had so many obstacles to overcome. The "Pique Load," a very clever skit, written and played by the girls of the San Diego Consolidated Gas & Electric Company, deserves special mention. It was not only very well received but also brought out the ten points contained in the "Common Sense Electricity" circular prepared by the accident prevention committee, N.E.L.A., 1929.

Under the capable leadership of Mrs. Marge Edwards, chairman of the safety subcommittee, there are now six well organized and active working First Aid teams in this division, and we are hoping that Arizona will enter one soon.

Los Angeles Gas and Electric Corporation—Captain, Ethel Brookelbank.

Southern California Edison Company—Captain, Marjorie Hobbs.

Great Western Power Company—Captain, Lucille Anderson.

Pacific Gas and Electric Company—Captain, Mrs. Ralph Hitchcock.

San Joaquin Light & Power Corporation—Captain, Mrs. Lillian Broeker.

San Diego Consolidated Gas & Electric Company—Captain, Mrs. Marge Edwards.

They are all doing very splendid work.

There are four of the utilities that have entries for the speaking contest. We regret not to be able to report all of them participating.

The public contact activities are very numerous. Many of the girls are affiliated with the churches, clubs, civic and city betterment organizations, and are helping with all community affairs, in fact, are recognized as leaders in their various localities. They act as hostesses at teas in various clubs, assist in getting up and putting over the programs, serve as members of committees in Community Chest drives, Y.W.C.A.'s, and Nutritional Homes, in fact, they are shining lights in their communities.

There are a number of Arizona utilities which do not have active committees, but Mrs. Roberts is working very steadily and earnestly towards an enlarged committee.

Mrs. Mabel E. Tripp, chairman of the subcommittee on home economics, has been making a survey of the territory and finds very little active work has been done along that line, with the exception of the San Joaquin Light & Power Corporation, which has always had a home service department. During the past year three talks have been made to women's organizations, one at a university, ten at high schools, eight cooking schools, fourteen church groups, five county fairs, and 1,800 house calls have been made. Mrs. Tripp is often assisted by our girls and at times other demonstrations are given in our building in the appliance department. There is also a cooking school in the building here sponsored by a local newspaper, under the supervision of a capable instructor. They have an average attendance of 100 every week and very often more. Every year at the county fair a tea room and rest room are maintained, with one of our girls acting as hostess. This is a very fine way to create a good will spirit. To carry on the work here, the girls sell candies and fruit at Christmas time and have cleared nearly $100 this season, with a present sum of more than $200 in the treasury.

All the committees celebrated Light's Golden Jubilee in a fitting manner, and also studied briefly the food preservation and refrigeration courses during the campaign.

Spring Meeting

The chairmen of the women's committee held their annual meeting in the San Joaquin Light & Power Corporation Building, March 20 and 21; all members were in attendance with the exception of Miss Jackson from Honolulu and Mrs. Roberts of Arizona. All phases of the work were reviewed at a round-table discussion.

On the evening of March 20, the women of the San Joaquin Light & Power Corporation entertained them at a dinner party at the Hotel Fresno. The morning of the 21st was given over to the home economics program and a full report of the national home service conference was given and copies of the report given to each chairman. During the noon hour we were guests at an electrically cooked luncheon in charge of Mrs. Tripp, home economics department, in the auditorium. This luncheon was given for members of the Commercial Section of the P.C.E.A. who were in session at that time. In

the afternoon the ladies were taken for a drive through the city, visiting all places of interest and through the famous Kearney Park, closing the day by having tea at a new suburban electrically equipped tea house. All returned to their work feeling that the two days had been very profitably and happily spent.

Purchasing and Stores Section[1]

The chief work of the year on the part of the Purchasing and Stores Section has been the initiating of a movement toward the standardization of line hardware. Machinery has been set in action through the Division of Simplified Practice of the U.S. Department of Commerce which should eventually lead to an adoption of standards for the entire United States. In addition several other committees have been active. Their reports will be submitted at a later time.

THE Purchasing and Stores Section for the year 1929-1930 was organized shortly after the close of the Del Monte convention in June, 1929. The first meeting was held in San Francisco on September 19, 1929, at which time the following committee chairmen were named:

Purchasing Department Organization & Procedure, E. F. Watkins.
Stores Department Organization, F. P. Hanson.
Material Control, H. O. McKee.
Surplus and Obsolete Material, G. H. Grummett.
Simplification of Stores Accounting, William Maddock.
Standardization of Material & Supplies, G. M. Richardson.

The second meeting was held in Los Angeles on Jan. 16 and 17, 1930. Reports and papers by the various committee chairmen and members were presented at this meeting.

The total membership of this section is now approximately 84, which is the largest the section has ever had. The meetings have all been well attended and much enthusiasm has been shown, particularly on the subject of the standardization of material and supplies.

The members of the Engineering Section have co-operated very fully and a joint committee between both of these sections has been formed further to study methods of standardization.

This committee's primary objective during the past year has been to centralize our efforts upon standardization. A final report by G. M. Richardson, chairman of the standardization of material and supplies subcommittee, is presented herewith.

As a further study for this section to be developed for the remainder of this year, a review is to be made of the major subjects handled since the inception of this committee eight years ago. A general questionnaire to the various member companies requesting information as to the effectiveness of the work done by this section in the past is now being prepared and will be submitted at a later date.

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[1] S. E. Hickman, San Joaquin Light & Power Corporation, chairman. William deWaard, San Diego Consolidated Gas & Electric Company, vice-chairman.
Central Arizona Light & Power Company: C. A. Hulse.
Coast Counties Gas & Electric Company: W. R. Van Bokkelen.
General Electric Company: W. C. Smith.
General Electric Supply Corporation: E. A. Hart.
Graybar Electric Company: H. L. Harper, H. T. Simmons.
Great Western Power Company: E. E. Behr, D. P. Mason, W. J. Shanahan, F. R. Sherwood, F. W. Smith.
Hubbard & Company: W. W. Glosser.
Joslyn Company: H. S. Detrick.
Kortick Manufacturing Company: J. C. Kortick.
Line Material Company: F. J. Gleiss.
Los Angeles Bureau of Power & Light: H. L. Caldwell, O. W. Holden, D. P. Nicklin.
Los Angeles Gas and Electric Corporation: C. B. Judson, William Maddock, M. A. McMillan, T. B. Parks.
Maydwell & Hartzell: E. S. Condon, H. F. Hartzell.
Pacific Gas and Electric Company: F. P. Hanson, J. H. Hunt, J. B. Madden, C. E. Young.
San Diego Consolidated Gas & Electric Company: R. E. Fritzer, A. S. Glasgow, G. N. Riblet, C. D. Weiss, F. A. Westrick.
San Joaquin Light & Power Corporation: E. R. Banks, G. H. Grummett, D. P. Mason, C. E. Schnell.
Southern California Edison Company: C. P. Altland, R. E. Brooker, Jefferson Davis, J. L. Gray, R. B. Guilbault, F. F. Henry, H. L. Hughes, C. C. Long, F. E. Maxey, W. J. McCullough, H. O. McKee, C. M. Mitchell, W. I. Priest, G. M. Richardson, E. H. Riggs, W. E. Row, D. C. Tandy, E. F. Watkins.
Southern California Telephone Company: G. E. Nott.
Southern Sierras Power Company: C. A. Kelley, C. B. Lore, E. B. Pennebaker, E. Y. Porter.
Westinghouse Electric & Manufacturing Company: A. W. Pride.

Executive Committee: S. E. Hickman, San Joaquin Light & Power Corporation, chairman. William de Waard, San Diego Consolidated Gas & Electric Company, vice-president; G. M. Richardson, Southern California Edison Company, secretary; E. E. Behr, J. H. Hunt, C. A. Kelly, Wm. Maddock, D. P. Mason, W. J. McCullough, H. O. McKee, F. W. Smith, E. F. Watkins, C. D. Weiss.

*Standardization of Material and Supplies**

For nearly two years the Purchasing and Stores Section of the Pacific Coast Electrical Association, a geographic division of the National Electric Light Association, has been studying the situation with simplification and standardization in mind. Early in 1928, Wm. Maddock, chairman of the Purchasing and Stores Section for 1928-29, appointed a committee with G. M. Richardson as chairman, to investigate and see what could be done in the matter of standardization and simplification. The committee is called the standardization of materials and supplies committee. The committee was formed from members of the purchasing and stores departments of the utilities represented in the Pacific Coast Electrical Association, together with representatives of the various manufacturers and jobbers of line hardware in California and was divided into groups to handle the work more effectively. The groups formed were on the following subjects:

1. *Line hardware.*
2. *Standard packages.*
3. *Insulators.*
4. *Simplified invoices.*
5. *Catalogs.*

The plan of the committee was to bring about the use of similar materials for similar purposes by the users within the state.

DUE to the peculiar requirements of the industry, it is not possible to use the N.E.L.A. standards in their entirety throughout the United States.

For the purpose of this report, the work of the two subcommittees on line hardware and standard packages will be discussed.

After working out a plan of action, lists of standard items of line hardware used regularly were obtained from each

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* Report of committee on standardization of material and supplies, Purchasing and Stores Section. G. M. Richardson, Southern California Edison Company, chairman.

of the ten utilities represented. These were tabulated and compared. The results were astonishing. Although each company believed itself to be well standardized and to be using the N.E.L.A. standards generally, the contrary was found to be the case.

The committee soon realized that the effect of such changes which would be necessary to induce uniformity in standards by the member companies would be so far reaching that, as purchasing agents and storekeepers, we could do little alone. The changes so involved the design of distribution and transmission lines that it became unquestionably a matter which involved the operating and design engineers of each company.

The original committee of purchasing agents and stores officials realized the economies possible through simplification and later standardization, but as the design of distribution and transmission lines was affected, the problem became one which extended beyond the recognized scope of purchasing.

Accordingly a joint committee of the Engineering and of the Purchasing and Stores Section of the P.C.E.A. was formed and the matter laid before the engineers.

After several meetings, it was decided to be impractical to attempt development of P.C.E.A. standards due to the extreme difficulty of co-ordinatnig the many standards in use throughout the industry. Many of the items used regularly by some of the utilities are special and not used by others, although from a purely practical standpoint, a standard item could be used. A great lack of uniformity was found in the use of many items of hardware. For instance; in the use of pole steps, four companies used ⅝-in. x 9-in. steps and five companies used 9/16-in. x 9-in., while one company used both sizes. In the ten companies mentioned, the sizes and varieties of flat cross arm braces exceeded those of the pole steps, there being eight distinct sizes used. Of eight companies reporting on the lag screws, the situation was similar, and so on down the list.

The manufacturers represented in the committee, after reviewing the situation, formed an association of line hardware manufacturers to do what they could to aid in simplifying the large list of items they found themselves called on to furnish. As manufacturers, they realize the excessive cost of producing non-standard materials and the economies which can be effected by a comprehensive plan of simplification and are naturally anxious to do anything they can to effect savings which may be passed on to the consumers. They realize that the higher cost of manufacturing special items and the expense involved in handling and storing stocks of these items, which move slowly, is usually absorbed by overhead charges which in turn are spread generally over the cost of all items manufactured, so that in reality the concern which purchases special items may unintentionally cause other customers of the manufacturer to help carry the burden of the cost, which probably is not reflected in the purchase price of the special article manufactured.

After corresponding with George A. Cooper, chief of the Division of Simplified Practice of the United States Department of Commerce, as well as the local Bureau of Foreign and Domestic Commerce, it was decided to request the Department of Commerce to make a simplified practice survey of the line hardware situation in the United States and to produce simplified practice recommendations, covering the various items. This will be done by calling together representatives of all manufacturers and users in the United States together with the various trade associations and technical societies, which might come into the picture.

It is a tremendous task to co-ordinate the activities, plans, standards and ideas of an industry like ours and produce such results as can be obtained by such a body as the Bureau of Simplified Practice. It is believed by the committee that a neutral body with the recognition that the Department of Commerce commands and with the resources that it has available, could do more in less time than any one group such as the Pacific Coast Electrical Association. The plan of action finally decided upon by the local committee was presented at a recent joint meeting of the Engineering Section and Purchasing and Stores Section, and received unanimous approval. A letter was drafted to the California State Chamber of Commerce, which has been selected by the Department of Commerce to represent it in its simplified practice activities in California, requesting that the survey be made and a simplified practice recommendation developed.

The letter was then presented to the executive committee of the P.C.E.A. for approval. The approval was immediately forthcoming, thanks to President E. B. Criddle, who personally followed the movement. The letter has now been presented to the California State Chamber of Commerce which will take the necessary steps to bring the matter to a conclusion.

The letter also includes the matter of standard packages for the various items of hardware, it being found by the committee that there is no uniform method of packing line hardware by the various manufacturers. Certain items may come packed in boxes, barrels, or burlap bags. Some may be packed in cartons. The quantities per package may vary to such a degree that it is difficult to handle, store, disperse and account for the materials. Some items are packed in such large quantities that the supplier often is asked to break packages, which is costly. Some packages are well made, while others are not. The poor packages break in handling due to the weight of their contents, or in the case of fragile items, do not protect their contents from breakage. The N.E.L.A. has done some fine work in developing standard packages for line hardware, but still inadequate packages exist. By co-ordinating the needs of the whole industry the Bureau of Simplified Practice can again do more than any one group.

Every purchasing agent, every engineer, everyone who has anything at all to do with the production or use of materials in quantities, should acquaint himself with the economies which result from simplified practice in any branch of industry. He will find that the possibilities are unlimited, and that the advantages are many. The economies already obtained in industry are tremendous. The economies which will be obtained are even greater. The elimination of waste in industry through this medium is a movement which should be supported without question by everyone in industry. There is no doubt that this simplification program will benefit industry and will benefit those who have had the foresight to subscribe to the principles of simplification and to put those principles to work.

The Department of Commerce has already worked out more than 100 simplified practice recommendations which have reduced waste in industry to an unbelievable degree.

After the completion of a simplified practice recommendation, the Department of Commerce will contact every manufacturer of merchandise, covered by the recommendation, as well as the larger users of such materials with a request that they sign a formal acceptance agreeing to adhere to the recommendations set forth as far as it is possible to do so. It will be found, however, that while most manufacturers welcome such a movement and sign the agreement to accept a simplified practice recommendation, that the consumers or users of material, while they agree generally on the worth of the movement, are slow in returning the users' acceptances. The effectiveness of the work done by the Department of Commerce is dependent largely upon users' acceptances. It is as important for us users of materials to make use of simplified practice recommendations as it is for the manufacturer to do so. We will agree that we should do everything possible to aid in the elimination of waste and to support, to the limit, a movement so productive of real economy. It is logical to believe that any

factory producing many varieties of each item manufactured could increase its production, lower its cost, flatten out its production curve, have greater stocks of finished products available, if it could eliminate some of the varieties that it is forced by its consumers to produce. The saving would naturally be passed on. By virtue of acceptance of the simplified recommendations, the user of materials would participate in the savings which would follow and which he has helped to bring about. One public utility in California has signed the users' acceptance covering eighteen simplified practice recommendations, and is doing all it can to see that only such varieties of each item covered can be easily obtained.

As purchasing agents, we are very close to the economic side of the question, but we must see that our design engineers are kept acquainted with the facts we are meeting with in our buying contracts. We must co-operate with them to the fullest extent before we shall see the results which we know can be obtained through simplification.

Everyone knows that the object of standardization is mass production and the economies which result from mass production. Everyone knows that the economies resulting from standardization are substantial and worth while. There is also now a general appreciation of the solidarity of industry, of the fact that all the different industries are bound together in one common interest, that any movement which is beneficial to a given industry, likewise, to a degree, benefits all other industries. The point here which I especially wish to emphasize is that national standardization is particularly a movement which is beneficial to industry as a whole. It is a universal economic solvent. No industry, or no company engaged in industry, can escape its benefits. It reduces the cost of what you make and sell, but, not less, it reduces the price of everything you buy.

Probably the first reaction of the man in the street when the subject of standardization is brought to his attention is that it checks initiative and hampers the introduction of improvements due to invention and ingenuity in the industries where it is applied. While at first glance there is a certain plausibility in this criticism, further thought will convince anyone that it is ill-founded, and that the tendency is the reverse of the one claimed.

Standardization, if kept within its proper limits, really stimulates, instead of blocking, improvements in the articles manufactured. It reduces the great mass of distracting detail into ordered form, so that the mind is free to exert its inventive genius toward improvement.

Of course standardization has corresponding advantages for the producer which are, naturally, indirectly of advantage to the consumer, among which may be mentioned:

1. He is not compelled to supply, for essentially the same purpose, materials ordered to a variety of specifications that may differ by just enough to require separate production under each specification, involving many classifications in production, in stock piles and the like, with no commensurate benefit to the user.
2. Under standardization, with respect both to dimensional and quality standards, the manufacturer, in times of general business depression, when his orders are low and buying is practically at a standstill, can continue to produce "standard" material, knowing that when business picks up there will be a market for it. In this way he keeps his plant running and his organization intact, avoids excessive labor turnovers, prevents large increases of overhead expense in relation to output, can frequently take advantage of favorable market conditions in purchasing raw materials, and in general maintain the efficiency of his operations. Such considerations as these are of great importance in that they substantially reduce the waste in industry, which is an economic burden upon the entire community.
3. The producer knows exactly what he is expected to furnish and how the material will be tested and inspected by the consumer, thus reducing to a minimum the possibilities of misunderstandings, which are both vexatious and expensive.

The joint committee of the Engineering and Purchasing and Stores Sections of the Pacific Coast Electrical Association will continue its work of simplification and standardization. The aim is to reduce the varieties of each item of line hardware and to reduce the number of similar items and finally to produce uniform standards for use by all member companies, which will bring about the many economies possible through such a procedure, all of which will benefit the manufacturer, dealer, user and the ultimate consumers served by the utility.

There follow the letters from the Pacific Coast Electrical Association to the California State Chamber of Commerce and also the letter from the California State Chamber of Commerce to the Division of Simplified Practice, United States Department of Commerce.

Office of G. M. Richardson,
Chairman, Standardization of Material and
Supplies Committee,
Pacific Coast Electrical Association,
146 N. Kingsley Drive,
Los Angeles, Calif.

January 17, 1930.

Mr. George L. Eastman, Chairman,
Simplified Practice Committee,
California State Chamber of Commerce,
Los Angeles, California.

Dear Sir:—

For more than a year the Purchasing & Stores Section of the Pacific Coast Electrical Association has been studying the matter of simplified practice and standardization as applied to manufacturers, suppliers, and users of pole line hardware.

It has been found that a very wide range of sizes, shapes, and kinds are regularly offered for sale in all parts of the country, many of which could be eliminated, effecting economies by which all concerned, including the public, would greatly benefit. In addition there are a considerable number of special items manufactured at the express request of the users.

The attached copy of the report made last year cites several examples of various items which are manufactured in California and elsewhere and used by the member companies of the Pacific Coast Electrical Association.

We believe that in view of existing conditions considerable saving may be made to industry, and recommend that you take the necessary steps to have the Department of Commerce make a simplified practice survey of all manufacturers, distributors, and users of pole line hardware and produce a simplified practice recommendation covering the common items of this class, including recommendations for standard packages for each item.

We offer every assistance to you and the Department of Commerce in bringing this work to a successful conclusion.

Yours very truly,

G. M. RICHARDSON, Chairman,
Standardization of Material and Supplies Committee.

Approved:
Executive Committee, P.C.E.A.
By, E. B. Criddle,
President.

Los Angeles, Cal.
March 5th, 1930

Mr. Edwin W. Ely, Chief,
Division of Simplified Practice,
Bureau of Standards,
U. S. Department of Commerce,
Washington, D. C.

Dear Mr. Ely:

The California State Chamber of Commerce, based on reports from its committee on simplified practice, requests the U. S. Department of Commerce, Bureau of Simplified Practice, to take the necessary steps to make a simplified practice survey of all manufacturers, distributors and users of pole line hardware in the United States, and produce a simplified practice recommendation covering the common items of this class including recommendations for the standard packages for each item, on a basis similar to simplified practice recommendation No. 18, covering builders' hardware.

For your information we are attaching a report submitted to our committee by the Pacific Coast Electrical Association, which is accompanied by data on seven items showing the need for simplification. The special committee of the Pacific Coast Electrical

Association has a complete list of all items of pole line hardware used by its member companies in California, which will be available on request.

Attached also is a partial list of proposed standard packages submitted by Mr. H. P. Seelye, chairman, subcommittee on hardware, insulators and wire, National Electric Light Association, who should be contacted by your department.

The Pacific Coast Electrical Association, through its simplified practice committee, desire to aid your department in every way possible in carrying out this request for simplified practice recommendations.

Believing this will receive your immediate and active attention, I am,

Yours very truly,

GEO. L. EASTMAN, Chairman,
Simplified Practice Committee.

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*Standards and Specifications**

THE elimination of waste is what we must all strive for and it seems to me simplification and standardization are means to that end. In order not to become unbalanced we must look at them as a means and not as the end. Saving does not necessarily result from spending less, but rather we should strive to get more and better results from what is spent.

Theoretically, it is easy and wonderful to advocate standardization, but often it is another question to carry it out in practice. It always seems standardization could fit the other fellow's job but that this particular task of ours is different.

If one would stop to realize what the standardization of the gage of the railroad and of vehicles has meant to this country, it would seem impossible to hesitate to extend its application further.

For the United States, see what the standardization of weights and measures and of money has done, but see the confusion that results at the borders when we meet a different system of weights and measures or of money.

Standardization of time in this country has become so common that probably few, if any, think of it and realize what it would mean if each locality carried out its own ideas, being governed by the sun.

Standardization, we must conclude, does pay, but to make it a success the individual must look to the whole and submerge his own desires to use something different. Standardization will not kill initiative, improvement and advancement.

Look at the American Telephone and Telegraph Company, highly standardized in methods of construction throughout the country—in fact many independent companies adhere to the A. T. & T. standards—and yet we all know that the telephone and the service rendered has advanced and is continually improving.

The incandescent lamp clearly shows what may be accomplished through standardization. Has this standardization in anyway blocked improvement? Not at all.

The carbon lamp of yesterday can scarcely in any particular be compared with the inside frosted lamp of today, for which the selling price has been reduced 53 per cent since 1914 and 50 per cent since 1920. You can buy two lamps today for what one would cost then and today's lamp will have a longer life, give better illumination and consume fewer watts.

Recording wattmeters, transformers, and motors are being standardized more and more—yet no one will deny the vast improvement that has been made in the manufacture of all of these and similar articles. With this in mind, we wonder why further progress is not being made in other lines.

Why should it be necessary, for instance, to have a number of styles of insulators for 6,600 voltage, when those insulators differ so immaterially. A half or even one-quarter inch in height is demanded; an eighth or a sixteenth of an inch in the diameter of the top groove seems necessary. It is hardly possible to think that a midway type could not be chosen for this particular insulator which would meet all requirements and effect a saving.

In bolts and lag screws and the like, improvement is being made—still there are those that now want them a half inch longer or shorter than many others, a condition which hardly seems necessary.

Wooden cross arms vary one-quarter of an inch in width or depth, and angle cross arm braces are not entirely standardized.

When we accept so many big far-reaching standardizations, it would appear that the task of standardizing the smaller things, where greater savings may be effected, should not be so difficult.

As an aid to standardizing in our campaign for elimination of waste, the supply department must have certain specifications upon which to work in procuring the material necessary for the job. It is not our province, responsibility, or desire to design and specify the material that is to be used in the construction of our plants and lines. That is the business of the engineers. Our task is to obtain at reasonable cost the things required and to have them on hand when and where needed, therefore we must rely on the engineers for the specifications we use in purchasing the material.

Already there are many specifications which have been tried and tested for long periods of time, such as those of the American Society for Testing Materials of the United States Navy and other government agencies and lately from the Bureau of Standards, Department of Simplified Practice. Again we must be careful not to let the means become the end, to let the tail wag the dog. Specifications are useful only when they will bring the right material to the job at a reasonable cost and when written with that in view will answer an admirable purpose, but when written to be a monument unto themselves, something to look at in wonder and awe, specifications will hinder rather than help the purchasing agent and the utility he serves.

If you are buying to specifications you must be equipped to test the material received, otherwise what use are the specifications? For example, I have in mind a company that purchased cedar poles upon certain specifications which differed considerably from the standards used by most producers and consumers. A number of the producers had never been able to get any of the business of this concern on account of higher prices, due to the fact that in order to meet the specifications it was necessary to classify the poles pretty rigidly. The unsuccessful bidders often wondered how the successful ones got by at the prices quoted, but later found the answer to the riddle in the fact that while the purchasing company had these rigid specifications, it had never tested or measured one pole received. The suppliers, knowing this, had simply figured the price on wood run poles and had shipped the same. Such information travels fast. Undoubtedly suppliers in other lines know the habits of this corporation and paid as much attention to meeting the specifications as did the pole producers. Now, to my mind, that company would have been better off without any specifications.

For many articles the best specification is the general reputation of the manufacturer for honesty and diligence and our experience with the actual service rendered from the material or apparatus purchased from that supplier.

We must avoid believing ourselves the only honest men and learn to rely upon the other fellow. Our task should be more to pick the right manufacturer than to pick the right manufactured article. In such cases competition would

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* Prepared for the committee on standardization of material and supplies, Purchasing and Stores Section, by C. A. Kelley.

not be barred, for all of us, I feel, could mention at least two reliable suppliers for articles that would come under this category.

Specifications, to be serviceable, must be common sense specifications. The purchasing agent should be trained or should have the assistance of those trained to know whether a specification furnished him is of the common sense variety, or merely the wild ravings of some idealist.

Too often the writer will make the specifications so elaborate and intricate that competition is practically barred and that there is little hope of obtaining the article at a reasonable cost.

Whenever possible, nationally accepted specifications should be adopted. The wider the range the use of any specification has, the simpler it will probably be and the more it will tend to standardization and to the results we hope to obtain by the elimination of waste.

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*Purchasing Department Organization and Procedure**

A preliminary report on the subject, "Purchasing Department Records," covered the following general points:

1. The necessity for a comprehensive system of purchasing department records.

2. Analysis and selection of essential data to be recorded.

3. Differences of opinion regarding departmental functions.

4. Lack of standard procedure to guide purchasing agents in developing departmental records.

5. Relation of purchasing to other departments, and importance of co-operation.

It was the intention of this committee to deal with the foregoing problems under three subject headings as follows:

1. Purchasing department functions.

2. Purchasing department forms.

3. Simplified records and office routine.

This report is presented in two sections: the first consisting of a general discussion of the program originally outlined, and the second devoted to a review of actual progress and results obtained by your committee in working out a simplified and practical system of purchasing department records.

Purchasing Department Records—Section I

PURCHASING DEPARTMENT FUNCTIONS

IT HAS been pointed out that an almost complete lack of uniformity exists in the interpretation of departmental functions among our various member companies, and the following comparisons of three companies have been cited as illustrative examples to show the difficulty of outlining a standard method of procedure under these conditions:

	Company		
	1	2	3
Invoices checked in purchasing department	Yes	No	Yes
Stores department under supervision of purchasing agent	No	Yes	No
Purchase orders originated in purchasing department	No	Yes	Yes

First, let us take the matter of checking invoices. There are arguments both for and against this work being handled in the purchasing department—and very good arguments on both sides, too. Most purchasing agents feel that in order to exercise proper control over a purchase from the issuance of the order to delivery of the material, it is necessary for invoices to be routed through their department for checking and approval. There can be little question but what this system affords the purchasing agent a somewhat closer contact with the seller, and keeps him better informed concerning shipments and general execution of his orders. Some purchasing agents go even further into the control of a purchase from order to delivery, by adjusting all O. S. and D claims through their department. Other purchasing departments will be found to include a division for handling traffic procedure, the sales of obsolete and salvage material, the supervision and disbursement of stationery stock, and what not. And in a few companies, the purchasing department does not even handle the buying of stationery and printing. So you see, it is rather difficult clearly to define the purchasing function and what it should embody.

Going back to the invoice routine, we find some excellent accounting authorities who contend that the checking of invoice prices, terms, transportation charges, f.o.b. points, etc., is strictly an auditing function. And in defense of this system, its advocates point out that an independent check by the auditing staff is more effective than could possibly prevail where control of the purchase from inception to approval of the invoice is confined within one department. Theoretically, the auditor's viewpoint is probably sound—he should be best equipped to check his company's activities from an unprejudiced angle. On the other hand, the purchasing agent will claim to possess the best equipment for making an intelligent check of invoices through his greater familiarity with the physical aspects of the transaction. But the auditor will probably reply to this argument by saying "Furnish me with a copy of your purchase order, showing complete information, and I will see that the seller's invoice is rendered accordingly."

This much is certain; no matter in what department the checking is done, full information must be shown on purchase orders if invoices are checked by clerical help unfamiliar with commodity prices, best methods of shipment, f.o.b. points, etc. If this information is not shown on the order, then the buyer is the only person competent to approve the invoice. And we all must agree that this method bears out the auditor's objection to having air-tight control of the transaction in the hands of one individual. Aside from that, and granting the buyer's absolute sincerity of purpose, it is extremely doubtful if he possesses the necessary auditing turn of mind to inquire as thoroughly into every detail of the invoice as will the accounting department staff which has been properly trained in this particular branch of the work.

Supervision of traffic routine, handling of claims, the sale of obsolete and salvage material, and decentralized purchasing are, like the invoice routine, variations which have come about through differences of opinion regarding proper allocation of authority, and they all are subject to much the same debate as the invoice question. It goes without saying, that all of us cannot be right in our diverse conceptions of purchasing department functions. However, it is not the purpose of this report to define the ideal set-up, but rather to promote some constructive thought on the subject.

Before we can go very far toward working out a standard purchasing procedure, it will be necessary to find out how we got into this muddle. In view of the comparatively recent development of constructive thought and modern ethics of purchasing, is it altogether surprising to find such conditions? Hitherto, it has been largely a case of every purchasing agent for himself, and the devil take the hindmost, both within and without his own organization. Undoubtedly a good many of our purchasing agents have in the past been regarded as a sort of "law unto themselves," maintaining a somewhat aloof and unapproachable attitude, and looked upon rather unfavorably by those with whom they came in

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* Prepared by W. I. Priest, Southern California Edison Company, for the committee on purchasing department organization, Purchasing and Stores Section.

contact. Would we be far wrong in saying that some of them have possibly been afflicted with a measure of egotism regarding their importance in the general scheme of things, and thereby have earned for themselves an unfavorable reputation through their failure to co-operate? If so, is it any wonder that they have floundered around in their own folly in the attempt to develop a systematic and efficient department single-handed, instead of soliciting the co-operation of those who possessed specialized knowledge and experience in such matters?

Certainly, when we look about us and observe the wide difference in the functions of various purchasing departments, it almost leads to the conclusion that many of them were originally the exclusive brain-child of the purchasing agent.

Happily for all concerned, these obstructive conditions are being remedied. Co-operation between purchasing departments and all whom they contact, is supplanting the old "Big I and little You" attitude, and with this change of viewpoint is bound to come improved relations and a gradual standardization of departmental functions. In the meantime it behooves all of us to contribute our best efforts toward the further building up of goodwill for the department which we represent. An efficient purchasing organization can render a multitude of important services in addition to the primary function of buying, but these additional features will only become apparent when approached in a helpful spirit.

Purchasing Department Forms

In comparison with other departments, the forms used in recording purchase transactions are few in number and relatively simple. Purchase orders, inquiry forms, price records, and address records will embrace practically all forms required in the efficient conduct of a representative purchasing department. These, of course, do not include forms which are peculiar to the individual department—for instance, confirmation memorandums for telephone orders, memorandums of purchase order corrections and changes, forms for recording data relative to vendors' reliability, etc. These forms vary so widely in their development and use that they can hardly be considered as standard records. Some purchasing departments handle purchase order changes by letter, rather than through the use of a form designated for the purpose. Some maintain elaborate records covering sources of supply and commodity indexes, while others combine this information with their price records. Of course, the number of forms required depends largely upon the scope of work performed. If the purchasing department takes in invoice routine, traffic, claims, etc., all these activities call for additional forms, but these likewise cannot be classed as strictly purchasing records.

Requisition Forms

On the other hand, we must consider at least one form which ordinarily does not belong in the purchasing department list, but with which we have to deal continually in carrying on our work—that is, the requisition. While the requisition does not originate in the purchasing department, it nevertheless becomes a record of vital importance to the purchasing agent, since it represents his authority for issuing the purchase order. Therefore, the purchasing department copy of requisition forms should be designed to provide convenient space for price quotations, suppliers' names, shipping instructions, etc., since this copy of the requisition is customarily used as the buyer's working paper and, in completed form, is usually the record from which the purchase order is prepared. So the purchasing agent should insist upon consideration for the heads of his department in the design of requisition forms.

Another important feature not to be overlooked is the size of requisitions, and this applies to all other forms as well. Much of the convenience and general efficiency of a form may be lost through failure to select a standard size of paper. Odd size forms do not fit standard files; they are awkward to refer to when filed with other papers, and they quite often add very materially to printing costs.

The ideal sizes for requisitions are probably 8½ x 11 in. (letter size) and 8½ x 7 in., depending upon the number of items ordinarily listed on one requisition. Letter size forms may be printed to read from the 11-in. side of the paper, or from the 8½-in. side, according to the most advantageous allotment of space and method of filing. The smaller size sheets are usually printed to read from the 7-in. side. So much for requisitions.

Purchase Order Form

Next in order, but of first importance from the purchasing viewpoint, comes the purchase order form. Purchase orders, we might say, are the records around which all purchasing department activities revolve. They represent the purchasing agent's principal and most frequent contact with the seller. Quite often they represent his only contact with a certain percentage of his suppliers. And while our purchase orders unquestionably carry a welcome message to the recipient, they may also perform a distinctly valuable service for us in addition to prompt delivery of the physical commodities they cover. If they completely describe our requirements, are clear in their shipping instructions, and cover all terms and conditions bearing on the transaction, leaving no loophole for misunderstanding and consequent delay or error, they cannot fail to promote a feeling of respect for the efficiency and businesslike methods of the purchasing agent whose name they bear.

The poorly constructed, incomplete or unintelligible purchase order will be just as distinctly unfavorable in the impression it creates. Is it not, therefore, definitely to our advantage to give careful thought and attention to the design of our purchase order forms, as the first step toward sending out a message which will command favorable attention when it reaches the addressee?

Excellent purchase order and inquiry forms may be worked out from the National Standard Zone System which was adopted at a national conference at the Division of Simplified Practice, Department of Commerce, Washington, D. C., Jan. 14, 1925. The arrangement of information under this system conforms to the style recommended by the National Association of Purchasing Agents and sanctioned by 70 other trade associations. It is part of the Division of Simplified Practice Recommendation No. 37, "Standard Purchase Forms." Full information and sample copies of these standard forms may be obtained by addressing the National Association of Purchasing Agents, Woolworth Building, New York City.

Ample latitude is provided in the National Standard designs to permit flexibility in their adaptation to the individual needs of any company in any line of business. Dimensions recommended are 8½ x 7, 11, or 13 in.; all sizes, of course, being arranged for mailing in window envelopes.

The number of purchase order copies to make is a question which concerns all of us, and one almost impossible to answer collectively, since it depends entirely upon the general organization plan and the routine methods of other departments. A careful study of the average purchasing department and its interrelation with other divisions of the organization would very likely reveal in most cases, that either too few, or too many copies are being made. And right here it should be emphasized that there is only one known method of bringing about simplification and economy in our work, and that is, by keeping everlastingly at it. A periodic check-up will show some opportunities for improvement, but to be truly effective in our efforts we must be continually on the alert for the

best method of performing the job at hand. Some of our purchasing departments are, without a doubt, issuing copies of purchase orders every day which are essentially useless, all because somebody requested them and nobody in the purchasing department has taken the trouble to find out whether or not they are being put to any practical use. On the other hand, an extra copy of the purchase order would, in some organizations, be a distinct benefit and a direct saving of time and money in one or more departments where it could be used to replace a more laborious and expensive method. Some of these very discoveries will be described in the second section of this report.

As to the method of producing purchase order copies, that, too, is a matter of preference and interdepartmental requirements. There are several good systems from which to choose. Where a comparatively small number of copies are sufficient, and the distribution does not vary, one of the carbon paper processes will usually be found satisfactory. However, in the case of six or more copies, and especially when the number varies according to several different classes of orders, a duplicating process will provide greater flexibility and produce more legible work. Another good feature of the duplicating method is the facility of making extra copies at a later date without retyping.

Make a study of the requirements of your department and your associate departments, not overlooking the vendor. He is entitled to some consideration, too—and if your purchase orders do not measure up to standard in appearance or usefulness, enlist the co-operation of all concerned and do something about it. Bear in mind, every purchase order tells a story of some kind..

Price Records

Price records have been developed under the influence of so many different ideas and opinions that no complete analysis of their merits and weaknesses can be covered in this report.

It is generally agreed that some system of price reference is necessary, yet there are purchasing agents who question the worth of such a record, especially when extended to cover all items purchased. The elaborate price record is often subjected to criticism on account of the labor and equipment cost of maintaining it. On the other hand, a modified system will usually develop some disappointing features in its operation. In the first place, the selection of items to be recorded under the modified plan is necessarily a matter of judgment, frequently the judgment of several persons. That, in itself, presents a problem, as scarcely any two individuals will agree on the relative importance of items to be posted. Furthermore, the modified record often has a tricky way of failing to deliver certain information when it is desired. Out of a clear sky somebody has occasion to refer to an item which it had been considered unnecessary to record. Right then and there the price record gets a black eye. Maybe the desired information was of no great importance, but nevertheless, all of us like to find what we want when we want it, and if it isn't forthcoming in short order, then it is human nature to condemn the thing that caused our annoyance.

In the second section of this report a simple and inexpensive price reference system is described. This method is at present in the experimental stage, but it appears to possess several worthwhile features.

Address Records

Address records, while important in the daily conduct of our work, offer no particular problem. So long as they are kept up to date and afford convenient reference, the form is a secondary matter. There are several good visible address systems on the market; however, a simple card record or loose leaf book is less expensive and may serve all purposes where the address list is comparatively small.

In concluding this outline of purchasing department procedure, it is desired to point out that no attempt has been made to cover all of the questions involved. There are many additional features worthy of our careful study, but in general, the methods discussed will govern just as effectively in dealing with these other steps. It has been the purpose to present sound principles, rather than to describe routine in this section of the report, for we must first understand something of the underlying causes of our problems before we can successfully work out their solution.

Possibly it may seem that we have digressed somewhat from our original subject in discussing departmental functions and policies, but it is obvious that these matters have a direct and important bearing on the systematic development of purchasing department records.

Review of Development of Purchasing Department Records of the Southern California Edison Company—Section II

It should be understood that our purchasing department records are still in the process of development. We expect to be developing them as long as we are in business. Conditions change; methods change, needs change; and we must keep pace with them, or else fall behind in the modern business parade.

With this thought in mind we started out, some two years ago, to reorganize our purchasing department and bring it up to as high a standard of efficiency as possible. To accomplish this would, we realized, require considerable time, and much study and investigation. But we believed the results would justify our efforts.

As the first step in this program, we requested our auditor to delegate someone from his department who had thorough training and experience in office organization and methods, to start us off on the right track. Our company's special accountant was assigned to this job, which required several weeks, but equipped us with the necessary plans and personnel to carry on from that point, using the material at hand.

Use of Duplicator

However, one marked improvement had been installed prior to the general reorganization just mentioned. We had been using a carbon paper process for producing purchase order copies, but this method did not possess sufficient flexibility for our particular needs. Our purchase orders are issued in a variable number of copies, ranging all the way from eight to twelve; and sometimes more—depending upon the requirements of other departments. One order may call for material to be inspected, necessitating two extra copies for the inspection department; the next may cover commodities purchased on contract, which requires extra copies for contract files, and so on. The carbon paper process was not adaptable to this condition, and did not produce clear copies when the number ran above six or eight. Another bad feature was the inconvenience of correcting typographical errors. Se we replaced this method with a duplicator installation, and have found the following advantages in its favor:

1. Enables typists to work with one sheet of paper, known as the master copy of the order.
2. Facilitates correction of typographical errors. Typist has only the master copy to correct.
3. Additional copies may be reproduced from original without retyping, even after several months in the files.
4. Flexibility—any required number of copies may be made from each original.
5. Permits checking of original and correction of errors before copies are made.
6. Miscellaneous uses—departmental instructions, bulletins, circular letters, etc., may be quickly and inexpensively produced.

Standardization of Purchase Forms

The duplicator also enables us to standardize our purchase order forms. Formerly, it was necessary to use a special form and a separate series of numbers for telephone confirmation orders, due to regular order forms being printed in a multiple strip of consecutively numbered sets for use in fanfold machines. This called for separate files for each class of orders, and complicated matters in general. Beginning with the change of equipment and continuing until quite recently, we had the original—or master copy—of our purchase order form printed and consecutively numbered in duplicating ink. Typing, of course, was done with a duplicating ribbon. Thus, the entire original was reproduced on all copies. While a decided improvement over the old method, we were never entirely satisfied with the appearance of copies reproduced from the printed portions of this form. It was always more or less trouble to obtain uniform results from order forms printed in duplicating ink, so we began to look around for a way to overcome that drawback. And just within the past two weeks we started using a new purchase order form which entirely solves the problem, to say nothing of a saving in printing costs and increased speed in operating the duplicator equipment.

The original of this new order form, and the vendor's copy are printed in purple ink, which of course does not reproduce when run through the duplicator. Purple ink was used in printing to match typewritten portion of order as nearly as possible. No other copies are printed; blank paper of different colors being used to identify distribution to our various departments. For instance, our general store copies are blue and buff; auditor's copy, green, etc. All interdepartmental copies show only the typed information, there being no necessity for the printed matter to appear on other than the vendor's copy and original. The original is our purchasing department file copy, and the printed form is necessary in this case as a guide in typing. Hitherto, all copies were made on white paper with departmental identification printed in upper corner. But colored paper affords a better method of identification and is less costly than printing. We were also ordering all copy paper punched for filing in loose leaf binders. Investigation revealed the punching unnecessary in the case of all but one or two departments, so we reduced the printer's bill a little more on that account.

Briefly, as a result of the duplicator installation we obtained:

Flexibility to fit our needs
Standardization of forms
Better appearing orders
More legible copies
Accuracy of work

Numbering of Purchase Order Forms

Beginning with our latest printing of purchase order forms we introduced a decided innovation in the method of their numbering; eliminating the use of order numbers assigned in the purchasing department and substituting the requisition number instead. In other words, the requisition number automatically become a purchase order number when it reaches the buyer. No numbers are printed on our present order forms. The converted requisition number is typed in the space provided, at the time the purchase order is written. For one immediate advantage, this saves accounting for all printed numbers, and eliminates waste due to numbered forms being spoiled in typing.

Before deciding to try out this numbering experiment we submitted the idea to all departments which might be affected by its adoption. And in every instance, after giving the matter consideration, the plan was approved. Practically everybody concerned expressed the opinion that the change would simplify their work.

At first, the idea appeared impractical from a purchasing department standpoint. Order numbers had originated in this department for so many years that we had come to look upon them as almost as necessary as the purchasing agent himself. Purchase order numbers were our trademark within the company, and our badge of identification to the outside world. However, taken by itself, that argument was largely a matter of tradition. Purchase order numbers are necessary, no question about it, but we reasoned it out this way: "Why isn't one number as good as another, so long as it serves the purpose of identification and reference? Centainly the vendor doesn't care what kind of a number we use; he only places it on our packages and papers to accommodate us, and because we request it." For a number of years we had been asking our suppliers to show both requisition and order numbers on their shipments, to enable us to account for them properly. Surely the use of one number instead of two would reduce the chances of error on their part, and resultant delay and inconvenience to us. Mistakes are costly, and avoidable mistakes a dead expense.

Returning to our own organization, we failed to find anybody who expressed the need for a special order number originating in the purchasing department. Requisitioners preferred to identify shipments by their requisition numbers; our accounting department found that the combination number would simplify their invoice routine, and so on down the line.

So the decision worked back to us, and by that time the plan had begun to look somewhat feasible. We were receiving a hundred or more requisitions every day. Why not use the numbers which they carried as our purchase order reference? Well, for one thing, it would upset our filing system. (We have more than a hundred authorized requisitioners, each with a different series of requisition numbers assigned by themselves.) Then why not make the filing system fit this condition, since it appeared that a combination requisition-purchase order number would be an advantage to all departments, with the possible exception of this one factor in the purchasing department?

We had maintained three separate files in connection with the old consecutively numbered orders. Requisitions were classified by origin and filed numerically, master copies of purchase orders were filed alphabetically by vendors, and a second copy of all orders was retained in the purchasing department and filed numerically in bound books. The alphabetical file presented our biggest problem in working out details of the proposed change, as all supporting papers except the requisition were attached to the master copy of the purchase order and filed under vendor's name in numerical sequence. Most of us considered this master file the virtual backbone of the department, as it was our principal source of reference. Even so, it was apparent that much of its convenience would be lost with the adoption of the new system, since all numerical reference value would be destroyed by the widely scattered series of requisition numbers. On this account we finally had to give up the idea of continuing an alphabetical file, and figure out some effective method of replacement. So we decided upon the following procedure:

An individual folder is indexed with each requisition order number, and all supporting papers filed therein. If two or more orders are issued from one requisition to different vendors, all are given the same number and filed in the one folder. These folders are classified according to requisitioners and filed numerically in their respective divisions. Reference to this master file is by number and requisitioner only. This set-up eliminated our alphabetical file entirely, consolidating it with the requisitions.

Next came the disposition of the purchasing department second copy of the order, since it was no longer desirable to file it numerically. We thought of discontinuing it entirely,

but one idea sometimes leads to another, and we hit upon a plan of filing this copy under commodity headings and using it as a buyers' reference. This file has just been started, but it appears to offer even more possibilities than we first expected. We believe it may replace our present price and commodity records after a few months' operation.

Now let us summarize a few of the advantages gained by this radical change in purchasing department procedure:

1. It is easier for the vendor to mark his shipments and render invoices correctly.
2. Purchase order forms simplified and printing costs reduced.
3. Placing of telephone confirmation orders simplified for buyers.
4. Simplifies identification of material received by requisitioners.
5. Reduces labor of posting store stock records.
6. Auditing and payment of invoices expedited through reduction of errors in billing.
7. Files may be consolidated throughout our entire system where purchase order copies and requisitions have been filed separately.

And we believe additional benefits will become apparent with further experience.

I have gone into considerable detail in describing this method of numbering purchase orders, because we devoted a great deal of time and study to its possibilities of success before reaching a decision to adopt it. We hope our experience will prove profitable to other Association members.

Receiving Department Copy

While on the purchase order subject, I want to mention one other feature of the new form which promises greatly to simplify the work of receiving clerks in our general store. These new forms are standard letter size, 8½ x 11 in., with the exception of one copy which measures 9½ x 11 in. After running through the duplicator, one inch is trimmed from the left hand margin of this copy, reducing it to standard size and providing an extra inch of writing space on the right hand margin. All quantities are removed by the trimming operation, but the copy is otherwise complete. This copy is turned over to the receiving department and used as their report of material received. Receiving clerks enter quantities only, as all other information is automatically taken care of. Hitherto, reports of material received were written out by hand. The new method eliminates incomplete descriptions, expedites checking of material received, and reduces the cost of clerical labor necessary under the old system. This is one example of where a very little extra work done in one department may effect a considerable saving in another.

Eliminating Misdirected Shipments

To be really efficient, a purchasing department must not only exercise good judgment in buying the proper commodities at fair prices, but also see that suppliers are furnished with definite and correct instructions regarding delivery. We all know the annoyance and expense caused by misdirected shipments.

During the past year we have reduced our troubles on this account to a minimum. Experience has taught us that requisitioners cannot always be depended upon to show specific addresses and shipping directions on their papers, so about a year ago we took the matter into our own hands and compiled a complete directory of company locations to which shipments of materials and supplies may be consigned. This volume, known as our "Traffic Bulletin No. 1," covers exact location, mailing address, and instructions for directing freight, express, and truck shipments to approximately two hundred and twenty-five points in our territory. Accumulation of reliable data for this bulletin required several weeks, but the information has proved almost invaluable in the correct issuance of purchase orders.

Some twenty copies of "Traffic Bulletin No. 1" are now rendering important service in a dozen or more of our other departments, and we receive frequent testimonials to their usefulness. This is another example of co-operation between departments for their mutual benefit.

Blanket Orders

Within the past few months we have simplified our purchasing department routine through the use of blanket purchase orders covering rubber stamps, business cards, and gasoline and lubricating oil requirements. Formerly, separate purchase orders were issued on each requisition received for rubber stamps and business cards. Two blanket orders, covering a period of one year each, now take care of our rubber stamp and business card requirements. Gasoline and oil orders now cover a period of six months, whereas we used to issue approximately one hundred and twenty-five new orders each month for deliveries of these commodities to various locations. Through these comparatively simple changes in procedure we effected the following economies: Reduced the yearly total of purchase orders for gasoline and oil from fifteen hundred to two hundred and fifty. Using an average of ten copies to the order, we will eliminate twelve thousand five hundred copies a year by this move. Rubber stamp and business card orders ran about one hundred a month. Reduced to one yearly order for each of these items, we will save nearly twelve hundred orders and twelve thousand copies over a twelve-month period. These represent economies in the purchasing department only, and we do not take into consideration the time and expense saved in handling requisitions, invoices and other papers throughout our system.

There are a number of other steps we have taken to simplify our purchasing department records and procedure, and at the same time render service to other departments, but the cases reviewed here will demonstrate what we are trying to accomplish, and the thought we endeavor to keep in mind, which is "Simple and direct methods without loss of efficiency."

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*The Purchasing Department—Why?**

THE reasons for the existence of any purchasing department are but two. First, it furnishes a means of providing materials necessary for the operation of the company; second, it obtains these materials at the lowest cost consistent with quality.

Under the first heading, the subject of interdepartment relations is important.

Interdepartment Relations

The purchasing department should be of assistance to other departments in many other ways than merely that of buying what is requisitioned. The buyer often is in position to know of new developments and devices that may not have come to the attention of others. Hence other departments should inquire of the purchasing department before departing upon a search for something needed, thereby, perhaps, saving a great deal of effort. It is also possible, for the same reason, that the purchasing department may be able to suggest a different article than the one asked for on a requisition.

The purchasing department should be of assistance to the engineering department in simplification and standardization matters, to the sales department in commercial matters, to the accounting department, stores, and construction departments in the daily problems that present themselves. In short, the purchasing department should be one rendering service to all other departments, never one supreme unto

* Prepared for the committee on purchasing department organization, Purchasing and Stores Section, by F. R. Sherwood.

itself, as the primary reason for its existence is to provide material for others to work with.

Under the second heading, the question of public relations is paramount.

Public Relations

Every buyer of merchandise and every seller must have confidence in each other to the extent that the buyer feels he is receiving fair prices, and the seller, that he is in turn receiving fair treatment at the hands of the buyer. Without such confidence the business of buying becomes one of skepticism and doubt on the buyer's part, and a feeling, on the part of the seller, that the buyer will take advantage of him unless he guards himself carefully. This sort of relationship does not tend to make business transactions friendly ones, and does incalculable harm to both.

Bids must be kept inviolate by the buyer. If prices are not kept secret, confidence is lost, and the respect of the seller for the buyer is gone forever. If prices are disclosed to a competitor, the competitor immediately suspects that the next bid of his own may be disclosed to another. There should be no exceptions whatever to the rule that quotations given a buyer are for his and no one else's inspection. Once a price has been given, it should be final. If a seller is given an opportunity to revise his price, due to market changes, altered specifications, or for any other reason, the same must be given to every seller interested, or the buyer has been guilty of unfair tactics.

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*Simplification of Stores Accounting**

Without attempting to provide a standardized system of accounting for the stores departments of all companies, this report suggests various simplifications in the method of handling stores accounts which will shorten the time required at the present time.

WE have assumed that the greatest benefit from the simplification of stores accounting will be the possibility of getting our final answer earlier than we are getting it at the present time. No system of accounting could be standardized for the stores departments of all our companies. The general set-up is very different. Some companies operate over a large territory and others are confined to small areas; but, in general, the answer we all need is a system that will enable us to supply the material when needed and to see that it is correctly disbursed and entered into the general capital and operating accounts of our companies. The detail of this work is tremendous and it seems proper to bring out some general thoughts on the subject.

Stock Record

The central point in the accounting connected with the stores department and the point from which all the other features radiate, is the stock record system. This might be a stock card, or a ledger, but some form of stock record is necessary as a guide to the purchase and usage of materials. The stock record should show:

1. The article fully described.
2. Date and number of storekeeper's requisition.
3. Quantity ordered.
4. Purchase order number.
5. Vendor's name.
6. Date material is received from vendor.
7. Quantity received.
8. Price paid.

The disbursing side of the stock record should show:

1. Balance of material on hand at all times.
2. Job number, account number and quantity disbursed.
3. Materials received which are returned on credits from the system.

Signalling Code for Ordering Materials

A signal system, depending upon the kind of record used, should be used to call attention to stock which has been depleted to the ordering point. The storekeeper should be advised at once when this condition of the stock has been reached, and it is recommended that a form be used for this purpose. This form should show:

1. The article.
2. Quantity on hand.
3. Ordering point.

This form should be sent to the warehouse and data checked with the warehouse stock to ascertain if the stock record agrees with the physical stock. If such is not the case, a signal should be placed on the stock record to show that the item needs investigation.

After study of the usage of this material, the storekeeper should place a requisition on the purchasing department to purchase an adequate supply. The purchasing agent should send to the stores department a copy of his order on the vendor. When the material is received, the storekeeper should send a certificate to the purchasing agent, certifying for delivery. Should transportation charges be necessary, a requisition should be sent to the transportation department or outside company to perform the work.

Defective material, or material delivered in error, should be returned to the vendor and signature obtained therefor on a proper return form.

Orders on the Storekeeper

No material should be issued without an order, nor should it be returned without a credit. Various printed forms can be devised to expedite this work. In general, all forms should show:

1. Article described in full.
2. Quantity ordered.
3. Quantity issued.
4. Where to be used.
5. For what use.
6. Account to be charged.
7. Job number.
8. Department.
9. Signature of stores department man issuing material.
10. Signature of man receiving material.

In the body of these forms it is well to have printed in alphabetical order as many as possible of the common items used, as this teaches the men the proper name of the material, as well as being more legible and, therefore, easier to post to the stock record.

It has been found an advantage to have a form printed for pipe orders and also one for wire orders, with tally record, and to allow no other materials to be issued on these forms, which are special for these articles.

It is advisable to use a color scheme to designate quickly charges and credits, charges being white with black printing and ruling, credits blue with red printing and ruling.

Methods of Charging Out Materials

The orders on the storekeeper should be posted to storeroom charges and each month a charge should be sent by the storekeeper to the departments withdrawing the material for all material withdrawn during the month. This charge should be signed by the department head, which should be

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Report of committee on simplification of stores accounting, Purchasing and Stores Section. William Maddock, Los Angeles Gas and Electric Corporation, chairman.
Los Angeles Gas and Electric Corporation: M. A. McMillan.
Pacific Gas and Electric Company: F. P. Hanson.
San Diego Consolidated Gas and Electric Company, G. N. Riblett.

sufficient certification that the material has been used and charged to the proper capital or operating accounts. This then can be entered in the ledgers of the company.

Pricing of Articles

This should be done by the price clerk whose duty it is to make prices. It has been my experience that the greatest differences between the value of the physical inventory and the book value have been caused by errors in pricing articles. There are several ways of pricing, but the simplest is that of an average combined price. Price sheets should be kept and a new price brought down each month.

Classification of Stock

In order to get more accurate inventories and distribute the work over the whole year, material should be divided into several classes and inventory of some of these classes can be taken each month. This method simplifies the inventory work and the entire stock is inventoried once a year. Stock such as tools, pipe and wire, if thought advisable, can be inventoried twice a year.

Inventory of Stock

An inventory card should be used for this work, originals of light weight paper with carbon back, and the duplicates of heavy card ruled alike. These should be numbered consecutively to avoid loss in collecting the cards. This card should show:

1. Article described in full.
2. Count as of certain date.
3. Material received after count.
4. Material issued after count.

When the cards are returned from the warehouse, they should be entered on a stock inventory sheet, and figures from stock card should be placed after the actual count figure, for the purpose of determining overage and shortage, and then priced and extended to show the value of the inventory of the particular class of material taken.

Control of Stock

The inventory value of a certain date, plus the value of the purchases, plus the value of material returned, minus the value of the material used, should be the value of the stock at inventory date, which should equal the book value. After careful research for errors, the value of the class balance should be adjusted.

Empty Container Records

Empty containers should be given a number and a record kept showing:

1. Name of vendor.
2. Vendor's number.
3. Description of container.
4. Order number.
5. Material received in container.
6. Amount charged.

Careful record should be kept of all movements of container from the time received until returned for credit.

Work Orders

All operations in the manufacture of an article should be done on a work order; all material and labor should be charged to this work order and brought back into the material and supplies account at the proper price of the finished product.

Sales to Employees

These should be made upon request if accompanied by a properly approved requisition. A bill of sale should always be given the employee and the usual standard forms of billing are the best.

Conclusion

The tremendous detail required in compiling these accounts is well known to all interested. The paper simply covers some points in general for the use of those laying out a simplified stores accounting system.

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*Contracts**

IT IS perhaps correct to say that all contracts covering the purchase of materials, supplies and equipment as well as construction contracts should be negotiated by the purchasing department of a utility, because this is a standard practice today, although it has not always been so.

As the negotiations are covered by the purchasing department, it also follows that it must assume the major responsibility for the details of the final contract itself.

There is often a tendency, in the rush of work, for the purchasing department to overlook the importance of certain details of the contract and this is to be condemned, for, although the contract is infrequently referred to in case of a dispute, it is important in these unusual cases that the contract be so worded that it would be interpreted in court to mean just what the purchaser intended.

It is usually impractical for the purchasing department to assume full responsibility for the financial details such as terms of payment, prices, etc., so the contract, before acceptance by the purchaser, should be referred to the engineering department and also to the law department for approval. It is important to note here that anyone examining a contract should have at least a general knowledge of the previous arrangements made and the engineering features of the work, together with a fair knowledge of contract lore. This is important because a statement involving a payment to be made contingent on the fulfillment of certain engineering requirements might be interpreted in three different ways, one each by the financial, engineering and law departments. It is desirable therefore, that one of the three, preferably the engineering department, should have a general knowledge of the other two features of the work, since it must assume responsibility for the economic efficiency of the project.

Routine on Contracts

A great deal of time will be saved in the handling of purchase contracts if the purchaser has his own form of contract which can be drawn up in a minimum of time and which makes use of standard clauses requiring that only the variable features be given separate consideration.

Many manufacturers have their own forms of standard contracts and these are checked easily by keeping available a copy of each of these forms for the inclusions and changes which it is customary to insist upon. If the endorsements on the contract agree with the changes in the sample it may be safely passed without detailed checking.

A scheme which promises to be of great value in eliminating detail work is that of having an annual contract, not only to cover lamps, poles and meters, etc., but also a general annual contract to cover major equipment such as transformers, generators and turbines.

This contract should be drawn up to cover all of the above types of equipment and would be supplemented by a purchase order which would be placed against it. Terms of payment, shipping instructions, etc., could be shown on the purchase order.

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* Prepared for the Purchasing and Stores Section, by J. H. Hunt.

In this way many large items that are now purchased on separate contracts and require considerable detail, could be covered by a purchase order with full protection in such items as infringement protection, guarantees, etc.

Construction Contracts

On construction contracts covering the furnishing of labor, materials and equipment there are certain details to be taken care of that are not included in the handling of contracts covering the furnishing of supplies.

The matters of particular importance concerning contracts with public utility companies are for the most part matters of importance in any contracts involving construction work and materials. Contracts contemplating large construction projects by public utilities can only be performed after obtaining the necessary consent of the Railroad Commission.

Aside from these special considerations which affect public utility contracts of a special nature, the following matters are of prime importance in the matter of all construction contracts made by the utility.

1. Promptness of performance is usually very important. Large sums of money are tied up in the project. The property cannot become operative until the work is completed and the liability of the company for taxes is therefore increased. Prospective income and development of the company await the completion of the contract. The project involved often requires months or years to complete at best, and every contractor must complete his job on schedule in order to permit the other contractors to proceed with their work. Consequently a definite date or time that can be guaranteed is inserted in practically every contract, before which the work must be completed. Time is made the essence of the contract, which permits the utility to declare a forfeiture or breach for failure to complete within the time specified, without notice or allowances. In many instances a provision is inserted giving the contractor a bonus for every day that he can save above the time fixed. More often a penalty clause is inserted providing liquidated damage for every day the contractor fails to complete the contract beyond the date fixed therein.

2. Protection against liabiliay for injury to the contractor or his employees under the Workmen's Compensation Law is another important consideration. Attention must be given to the terms of the contract so as to avoid possibility of it being construed as a contract of employment, rather than a contract with an independent contractor.

This is secured by avoiding provision for detailed control and direction by the utility of the methods employed by the contractor and his employees. A lump sum contract price for a given job presumes that the contractor is an independent contractor rather than an employee and therefore that he and his employees do not come within the provisions of the Workmen's Compensation Act as respects the utility. We further protect ourselves in this matter by requiring the contractor to carry the necessary compensation insurance and the insertion of a provision in the contract to that effect raises a presumption that the relationship is that of an independent contractor.

3. A third consideration is protection against liability under the Mechanic's Lien Law. This is secured, first, by requiring the contractor to furnish a bond running both to the utility and to all material men and mechanics employed by the contractor in connection with his performance of the contract. Secondly, we record the original contract and bond before commencement of work, which limits the utility's liability to mechanics and material men to the amount due under the contract to the contractor. In the third place, the contract provides that a substantial portion of the contract price shall be withheld until over thirty days after the completion of the work, which permits the utility to file a notice of completion of the work within ten days after said completion, thus shortening the period within which a mechanic's lien may be filed, from ninety to thirty days. Thus the period expires before the final payment is made. If liens are filed within the thirty day period, then the utility may apply any portion of the withheld contract price to remove the same.

4. Protection against fire and public liability are other matters that are often provided for in the contracts. The matter of securing public liability protection by provisions calling for the securing of appropriate policies has proven a difficult problem. It is difficult to find an insurance carrier who will furnish a form of policy that really gives the utility any protection, for the reason that such policies, if insuring the utility alone, exempt the insurance company from all liability caused by any negligence of the utility or its employees. As it is difficult to conceive of the utility being liable in the absence of actual or presumed negligence, this exception makes the policy practically worthless. On the other hand, if the policy insures the utility jointly with the contractor against public liability, it exempts recovery for injuries to the property and employees of both the contractor and the utility, even though the injury to the property or employees of the contractor (or utility) may be caused by negligence of the utility (or the contractor). This subjects the contractor or utility to liability of suit by persons against whom the utility or contractor can not protect themselves, either by public liability insurance or workmen's compensation insurance.

In order to be certain that the contractor is properly and fully covered on public liability and property damage, it is good business to insist on the contractor submitting his policies for examination by your legal department. You will be surprised at the number of policies submitted under which you are not fully covered and on which it is necessary for the insurance company to attach riders giving you full coverage.

5. The matter of requiring bonds on construction contracts depends very much on the standing of the contractor. In a case where you have had a number of previous contracts with a contractor and all contracts have been completed satisfactorily in every way, it would appear to be in order to waive the bond. On the other hand, if the successful bidder on a job happens to be a contractor with whom you have had little or no previous experience, it is well to insist on a bond.

Numerous other matters might be mentioned which become important in different types of contracts, such as protection against patent infringements, performance guarantees, covenants to replace defective parts, etc. However, the foregoing discussion covers the matters with which the utility is generally more particularly concerned.

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*Reciprocity in Purchasing**

RECIPROCAL purchasing is a subject which involves many angles. Fundamentally it is the old story of "You did something for me so I am glad to do something for you." If I today borrow a dollar from you and tomorrow you come along and want to borrow one from me, I would be ungrateful if I did not reciprocate and let you have it. That's reciprocity—isn't it? In its simplest form its application is easy of determination, but in business it does not always appear in such form and cannot always be so easily measured. Did you hear—sure you have! "I purchase my requirements from you so you should buy yours from me." "I use your power so your requirements in my line should be purchased from me." If that was all that was involved it would be simple, but there are many other factors to be considered in a business such as ours. There may be those who do not purchase anything from us, but from the angle of reciprocity through rendering a service and their contribution to the growth and success of our business, should receive equal and, at times, preferential consideration.

The day of the old methods of purchasing, whereby everyone is for himself and "The Devil take the hindmost" is fast passing, and the position of the purchasing agent is placing buying on the plane where it belongs. "In the good old days"—how many times do we hear that? How would you like to go back to the horse and buggy, unpaved streets, cinder sidewalks, kerosene lamps, the old well with a bucket and its rope, horse cars or walk, telephones at the corner drug store where you only could talk a few miles? Those were the "good old days." Yes, they were! I'll take the present days—and I don't know who wouldn't, do you? Well, anyway, those were the days when the executives of a business would say to a purchasing agent, "Your job is to get the best possible price—your success as a purchasing agent is going to

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* An address by H. L. Harper, Graybar Electric Company, delivered before the Purchasing and Stores Section at its Fresno meeting, April 16, 1930.

be measured solely upon your ability to get the best price." Maybe someone heard of reciprocity in purchasing in those days—I expect they did, for friendships and expressions of gratitude have always been one of the foundation stones of civilization.

This is a new era. The progressive executive today is the one who lays down a policy for his purchasing agent to follow, and sees to it that he views his responsibilities on the basis of the over-all problem of his company's business, and in addition considers the economic structure of his community's welfare and those with whom he does business, and also follows practices which are recognized as ethical. I want to pay tribute to the principles of purchasing as laid down by the National Association of Purchasing Agents and the good work which they are doing to educate business upon the importance of observing the principles which they enunciate. They are making a valuable contribution to all business through recognizing fair dealings for all and by strengthening the fundamental and economic position of all business and enterprises. This, when all is said and done, is the very foundation of our country and the medium through which employment at good living wages and prosperity and happiness are disseminated to our people.

It strikes me that there are some clearly defined fundamentals involved which we should take into account when doing our buying:

1. *The Responsibility of the Concern With Whom We Are Considering Placing Business*—Such factors as financial ability to perform satisfactorily on contracts awarded, antecedents on previous performances, capacity, character, honorable and ethical dealings under all conditions, are to be considered.

2. *Activities and Co-operation Which Contribute to the Development and Success of Our Business Are Important Factors to Have Always Conspicuously Before Us*—We are involved in an industry wherein one branch is more or less interdependent upon the other. The channel of flow is from the manufacturer to the wholesale distributor, and from them to industry, and to the contractor-dealer and so to the public and the lines of the power companies. Each branch of the industry and each company affiliated with the industry has an opportunity for promoting the idea of the use of everything electrical, thereby eventually making this, as we all desire, a truly electrical age. I submit that there is a reciprocal relation involved in the rendering of such service, for the problem is such that there is an opportunity for each of us to make a contribution of value to the other's business. "Together we stand, divided we fall," together we promote each other's welfare, together we each succeed.

3. *Quality, of Course, Always Occupies an Important Position*—When we think of quality we should consider not only durability and life, but per annum cost. When we think of per annum cost we should have in mind all elements involved, such as cost of replacement of the article itself and in addition the labor involved in making replacements and service interruptions.

4. *Service, In Its Truest Sense and All That It Implies Should Always Be Considered.*

5. *Price. I Have Left This to the Last, for in My Estimation It Is the Last Factor Which Should Be Considered*—To be sure, price is an important element, but by no means is it the sole factor, nor do I think it is first in importance. But unfortunately it is too frequently so considered. We could all buy many materials cheaper than those which we purchase, and why don't we? Because there are involved fundamental principles other than price. Quality, service and other factors remain long after price is forgotten. As we review this subject, isn't it apparent that there are many angles to reciprocity in purchasing, and interallied with it to the broad over-all problems of our business as a whole? We should have the viewpoint of the executive and place our business on such a basis as will result in the success, not only of our individual company, but of our industry as a whole. While so doing we have before us the economic structure of all of those with whom we do business, to the end, as previously stated, that we will be making a contribution to the success and happiness of all people. When all is said and done, what else is there to life? We are born today and, like a blade of grass, are gone tomorrow, so should not all our endeavors, both business and personal, be to the end that we and our fellow associates get the most out of and enjoy life to the fullest?

Transportation Section[1]

*Section Activities**

The importance of motor vehicle equipment to all branches of the electric light and power industry is emphasized in the reports of all Transportation Section committees this year. Statements of capital investment and operating costs are given, with illustrations showing modern automotive vehicles, painted in harmonious colors and equipped with labor saving devices and every modern convenience to meet the specialized need of the user. One of the important contributions is the presentation of a standardized motor vehicle cost ledger and monthly cost report of data required by superintendents to operate a fleet of motor vehicles efficiently.

THE scope of the activities of the Transportation Section of the Pacific Coast Electrical Association has expanded to such an extent that it became necessary this year to increase the number of standing committees and to define more clearly the functions of each committee, as outlined on the accompanying diagram. A diagram of the personnel of the committees of this Section is also given.

New Activities

In outlining the scope of activities to be conducted during the year 1929-30 it was decided to make extensive studies of the problems of greatest importance to the users of motor vehicles, as well as to other branches of the electrical industry affected by motor vehicle operation. For example, consideration was given to such subects as "Well Trained, Courteous and Capable Truck Drivers," "Pleasing Appearance and Design of Motor Vehicles Properly Equipped With Labor Saving Devices," and "Economical Operation Cost." An attempt has been made to co-ordinate the Transportation Section activities with all other Sections of the Pacific Coast Electrical Association.

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[1] Executive Committee: C. D. Weiss, San Diego Consolidated Gas & Electric Company, chairman. E. C. Wood, Pacific Gas and Electric Company, vice-chairman; W. E. Frazer, San Diego Consolidated Gas & Electric Company, secretary. V. W. Dennis, P. H. Ducker, C. H. Gray, S. B. Shaw, J. M. Wainscoat.

* Report of chairman, C. D. Weiss.

In the following resumé of Transportation Section activities there are described briefly the subjects covered in Transportation Section reports that are of general interest to other Sections of the Association.

Public Policy Section—

1. The safe-guarding of our member companies' interests by keeping conversant with the interpretations of the Motor Vehicle Act, its adoption of new laws and the revision of old laws. 1928.

Public Relations Section—

1. Training and selection of drivers—(This included all matters pertaining to drivers' and operators' contact with the public, their personal appearance, and strict observance of motor vehicle laws and local traffic ordinances, etc.) 1926, 1930.
2. Prevention of accidents—1926,1930.

Engineering Section—

1. Automotive labor saving-devices—1924, 1926, 1927, 1929, 1930.
2. Selection of automotive equipment and body design including material and tool boxes and facilities—1926, 1927, 1928, 1929, 1930.

Commercial Section—

1. Electric trucks, selection and application—(This subject also included methods of merchandise delivery, design of holders or brackets to display merchandise advertising matter.) 1926.

Accounting Section—

1. Automobile records and accounting practices—1926, 1927, 1928, 1929, 1930.
2. Cost of operation—1924, 1927, 1928, 1929, 1930.
3. Hourly versus mileage charge basis—1924.

Purchasing and Stores Section—

1. Pole and material deliveries, equipment used and methods of control—1926, 1927.

Advertising—Publicity Section—

1. Subject matter discussed and published that is of greatest interest to this Section is contained in the papers, "Selection of Automotive Equipment," in which there was included all matters pertaining to the securing of approval from company executives for the purchase of good-looking, modern and up-to-date motor vehicles, properly lettered and painted, and the control of general appearance and arrangement of the materials carried. This has been noted as being equal or better in value to the best newspaper publicity. 1926, 1927, 1928, 1929.

Insurance Section—

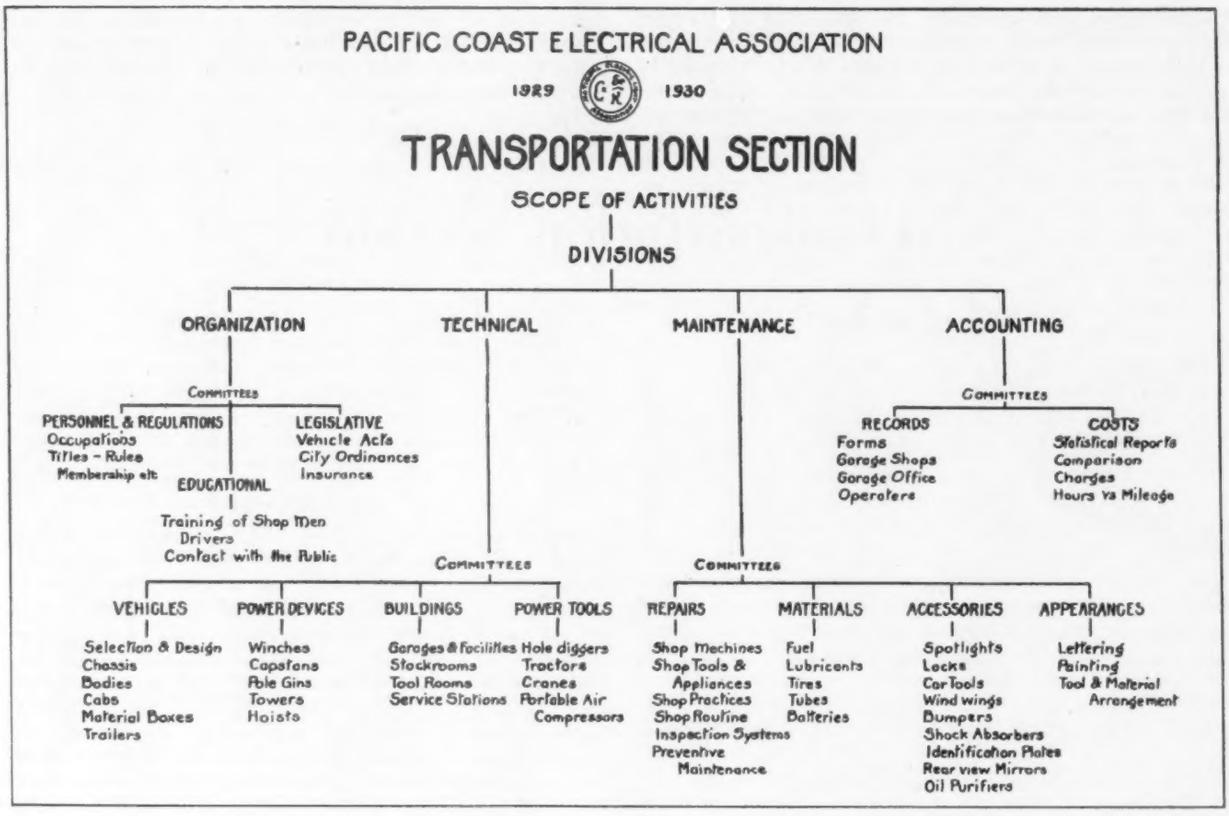
1. Insurance practices of member companies vary, as a number of companies carry their own motor vehicle insurance. However, there are many phases of insurance which are of interest to all member companies. Recent legislation concerning motor vehicle insurance makes close study necessary by the utility companies. Company and employee liability, fire, theft, collision, public and personal liability insurance are features of importance to Transportation Section activities. 1927.

Membership Section—

1. Association memberships were discussed, and a former Section chairman enrolled more than 150 new members in the Association, designating their affiliation with the Transportation Section. This proves that all Sections can greatly increase the Association membership enrollment by well directed effort. 1927.

Transportation Section—

1. Garage design.—1926, 1930.



Motor Vehicle Capital Investment and Operating Expense of Member Companies of the Pacific Coast Electrical Association

Capital Investment

Total number of vehicles owned (including trailers)	6,792	
Original cost		$ 9,718,739.71
Garage buildings and yards (four companies not reporting)		2,800,934.92
Shop equipment and tools (two companies not reporting)		359,529.33
Total investment		$12,879,203.96

Operation Expense (12 months ending Nov. 30, 1929)

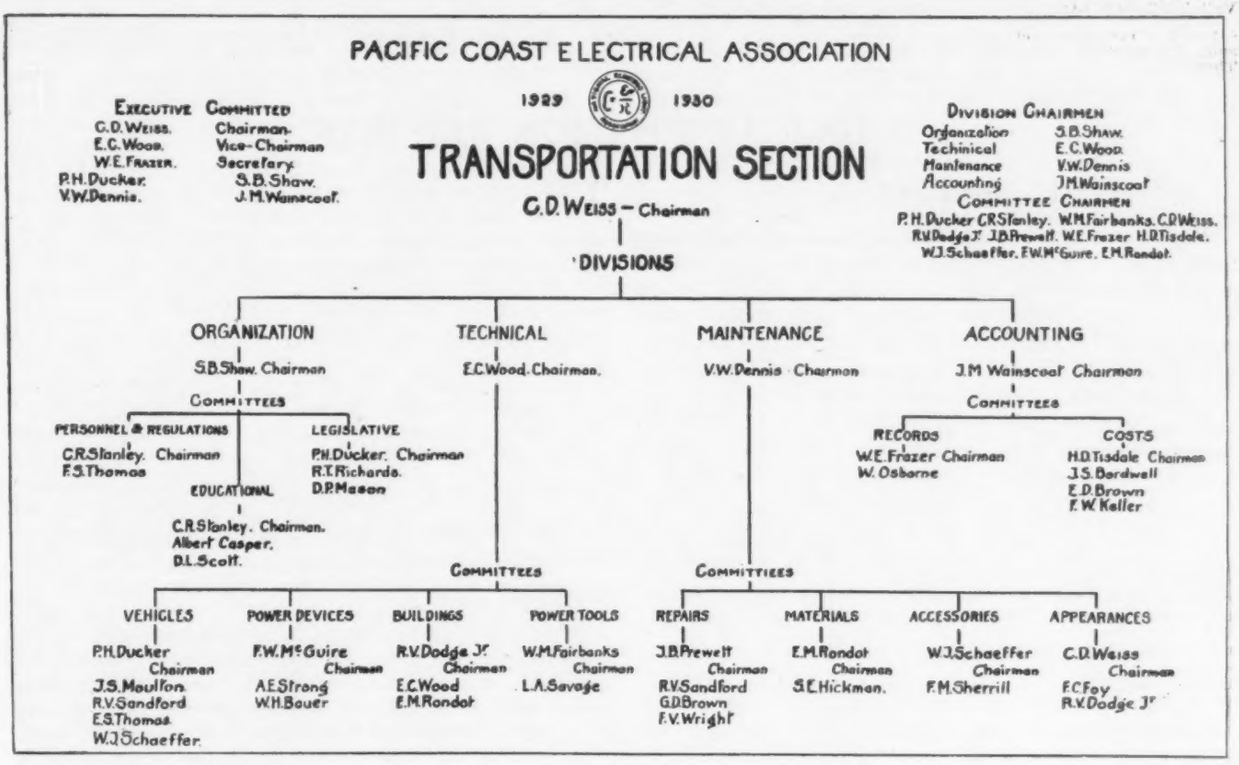
Total number of vehicles owned (including trailers)	6,792	
Total operation expense		$4,970,214.60
Total miles run	54,673,833.00	
Average cost per mile, all vehicles		0.099
Rented vehicle expense (five companies reporting)*		482,594.74

*Reports on this item incomplete

Reports received from several of the large member companies were incomplete. However, the figures obtained give some idea of the magnitude of transportation costs.

It is estimated that the total capitalization of vehicles owned by member companies of the Pacific Coast Electrical Association exceeds ten million dollars, and that the value of buildings, grounds, shop facilities, and tools is about five million dollars.

The total operating expense of a twelve-month period, including leased and rented equipment, amounts to more than five and one-half million dollars yearly.



2. Gasoline efficiency, storage, quality, etc.—1926, 1927, 1928, 1929, 1930.
3. Lubrication, equipment and practices.—1926, 1927, 1928, 1929, 1930.
4. Maintenance and operation.—1924, 1928, 1929, 1930.
5. Organization.—1928, 1929, 1930.
6. Shop equipment and methods; tools.—1926, 1927, 1928, 1929, 1930.
7. Special problems.—1927, 1928, 1929, 1930.
8. Standard titles for transportation department.—1929.
9. Tires, care of.—1926, 1929.
10. Training of shop men.—1926.

It may be seen from the wide scope of activities conducted by the Transportation Section that joint studies of the activities of common interest to the other Sections of the Association will be of great benefit to the construction and operating departments of member companies. Such departments are heavy users of motor vehicles and labor saving devices.

The statistical report of capital invested and yearly operating expense which is published on subsequent pages still further indicates the importance of motor vehicle activities to all branches of the electrical industry.

In summing up the work of past activities the members of the Transportation Section desire to recommend to the officers and directors of the Pacific Coast Electrical Association, that executives of member companies appoint representatives from construction and operating departments to become members of the transportation section.

National Transportation Section

The formation of a National Transportation Section would greatly enhance the Transportation Section activities of the geographic divisions and eliminate the existing overlapping of work between geographic division transportation activities and the transportation activities conducted by numerous national section subcommittees of the N.E.L.A. Therefore, the members of the Transportation Section of the Pacific Coast Electrical Association recommend the formation of a National Transportation Section of the National Electric Light Association.

ORGANIZATION DIVISION REPORTS[2]

Personnel and Regulations[3]

SOME progress was made by this committee in the preliminary preparation of a set of rules for drives and transportation department employees.

A set of standard drivers' examination requirements consisting of driver's ability, physical condition, personal appearance and general knowledge of motor vehicle acts and city ordinances is in the course of preparation for presentation the coming year.

[2] S. B. Shaw, Pacific Gas and Electric Company, chairman.
Central Arizona Light & Power Company: R. T. Richards.
Coast Counties Gas & Electric Company: F. S. Thomas.
Great Western Power Company: D. P. Mason, J. S. Moulton.
Los Angeles Gas and Electric Corporation: D. L. Scott.
Pacific Gas and Electric Company: C. R. Stanley.
Southern California Edison Company: P. H. Ducker.
Vallejo Electric Light & Power Company: Albert Casper,

[3] Report of personnel and regulations committee, Organization Division, Transportation Section. C. R. Stanley, Chairman. F. S. Thomas.

Educational[4]

This committee conducted informal discussions at the meetings and prepared preliminary plans for the continuation of the work during the coming year.

Legislative[5]

This committee made a thorough study of the revised California Vehicle Act of 1929 and prepared a circular of the important additions and changes for the benefit of the Section members.

This committee contacted with executives of the State Motor Vehicle Division on several matters.

[4] Report of education committee, Organization Division, Transportation Section. C. R. Stanley, chairman. Albert Casper, J. S. Moulton, D. L. Scott.

[5] Report of legislative committee, Organization Division, Transportation Section. P. H. Ducker, chairman. D. P. Mason, R. T. Richards.

TECHNICAL DIVISION REPORTS[2]

*Motor Vehicles**

The fact stands undisputed that motor transportation today is one of the important factors in the operation of a public service company's business for by means of modern transportation practically all other departments are enabled to function in an efficient and satisfactory manner. To the motor vehicle committee has been assigned the task of analyzing the problems of selection of motor vehicles and their assignment to the various departments and jobs in the respective member companies.

[2] E. C. Wood, Pacific Gas and Electric Company, chairman.
Coast Counties Gas & Electric Company: A. E. Strong, F. S. Thomas.
Los Angeles Gas and Electric Corporation: W. J. Schaeffer.
San Diego Consolidated Gas & Electric Company: R. V. Dodge, Jr., L. A. Savage.
Southern California Edison Company: W. H. Bauer, P. H. Drucker, F. M. Rondot.
Southern California Telephone Company: W. H. Fairbanks.
Tucson Gas, Electric Light & Power Company: R. V. Sanford.

* Report of vehicles committee, Technical Division, Transportation Section. P. H. Ducker, chairman. J. S. Moulton, R. V. Sanford, W. J. Schaeffer, F. S. Thomas.

THE types of vehicles suitable for use by a public utility have changed so rapidly that great economies can be effected through careful study of the assignments of the right vehicles to certain jobs.

Classifications of Vehicles

Transportation facilities can be separated readily into two broad classifications:

(*a*) Passenger carrying vehicles.

(*b*) Commercial and cargo carrying vehicles, including those equipped with labor saving devices, line trucks, etc.

Selection of Passenger Cars

In the following discussion we will first consider passenger cars.

Preliminary Considerations—

Before a request is placed with the transportation department for the use of an automobile, certain investigations should be made by the head of the department requiring such service. It should be decided whether the car is needed all or only a portion of the employee's time. In certain cases, it may appear advisable to recommend that the employee's

personal car be rented rather than to assign a company owned vehicle.

In this connection there has arisen some difference in opinion concerning the advisability of the use of personally owned automobiles in company service. However, this is an open question and the general policy of the company should be followed in this matter. As a matter of convenience, however, in this paper, we will assume that the use of personally owned automobiles under agreements is acceptable. In these agreements, provisions should be contained regarding insurance coverages for the protection of the company's interest and standards for maintenance and appearance should be set.

After the department interested has come to the proper conclusions and all necessary approvals of executives are obtained, a request should be made to the transportation department to furnish suitable transportation facilities. This then places the matter of selection and assignment up to the transportation department.

From the formal request for transportation, the head of the transportation department must determine if a company automobile is to be used; if the employee is to have an automobile assigned to him or if he is to use one which is in the pool; that is, one which is used by any number of employees when occasion requires.

If the transaction requires the assignment of a vehicle, the next decision must be the selection of a proper machine. One of the first questions is whether or not there is in the company's possession a suitable automobile available for transfer to this work or whether it will be necessary to purchase an additional vehicle.

If a new vehicle is to be purchased, there are several items of importance to be decided.

Open vs. Closed Models—

First—Will it be an open or closed car? The question of closed or open cars is one that until recently has been that of investment, but new developments in production indicate that the cost of closed cars is practically the same as that of open cars, and the output of closed cars represents between 80 and 90 per cent of the total, whereas formerly the open cars represented 80 or 90 per cent of the total production. Popular demand for closed cars will soon result in increasing the cost of open cars beyond that of closed models. The opinions of representatives of the several member companies were unanimous that closed cars should be used in most all classes of work. In addition, the trade-in allowances for open cars are generally lower than those for closed cars, which tends to increase the ultimate cost of the open models.

Light or Heavy Types—

Second—The next question is whether it will be a light or heavy car. By light cars is meant those costing under $1,000 as compared to those costing over $1,000. Some department heads of member companies have maintained that the necessity of employees using the higher priced cars was due to the fact that the employee must create a dignified impression when calling upon outside people. However, the question seems to be answered by all member companies that these lighter cars are, as a rule, adequate for all employees except where the management feels it necessary, as a matter of prestige, to use a heavier car.

Several points were brought out in the answers to inquiries which justify the use of a smaller car, such as the fact that customers have congratulated employees upon the economy practiced in the purchase of the less expensive cars and, with the new design of motor cars, the riding qualities have been found to be practically the equal of those of the medium priced vehicles. In determining whether open or closed models, or light or heavy types be purchased, consideration should be given to the average daily mileage, road conditions, and prevailing weather.

Seating Capacity—

Third—Will it be a two- or five-passenger car? This, of course, is a matter which can only be decided through an inquiry and investigation as to the actual needs of the employee who is to use the car.

Insignia—

Fourth—The next question is: "Should the company's name or emblem be placed upon the vehicle?" The answers to inquiries indicate that there is no definite practice and there are differences in opinion in regard to the value of the company's name being placed on passenger vehicles. This is subject to local conditions and should be governed by rulings set down by the managements. It may be detrimental to the company's interest to display the name on cars on certain assignments.

Trucks

The selection and assignment of trucks to various departments is a matter which should call for the most careful consideration by the head of the transportation department and his assistants. For without question economy or extravagance can enter into this phase of the operations.

When a department head requires the use of an additional motor truck he should ascertain definitely the complete service which will be required of this truck.

Conditions Governing Selection—

What is the maximum weight, including crew, to be carried? What territory will be served? What are the road conditions which will be encountered? Will any labor saving devices be placed on the vehicle? What average road speed is desirable? Specifications containing answers to these questions should be sent to the transportation department for guidance in determining the make and model of vehicle which will fulfill the demands of the department operating the truck and give the most economical and satisfactory service. It must be remembered that in making selections of equipment, local and state regulations must be complied with, and there are restrictions on gross weight of trucks and the speeds at which they may be operated. In operation, overloading and speeding should be avoided, even if within the law, because truck chasses are designed for definite loads and speeds. If these are exceeded, delays will occur from premature mechanical failures and economical operation will not be obtained.

Considerations of Replacements—

Closely related to the problems of original assignment is the universal one of replacements, as motor vehicles both depreciate and become obsolete at astonishing rates. When is the economical time to replace equipment, or to purchase a new car for one assignment, transfer the vehicle now in the service to a second assignment, and to retire the one on the second assignment? These are deep questions which must be worked out by the transportation chiefs, aided to a large degree by the heads and members of the departments operating the vehicles.

Old Basis for Replacements—

In the past, several arbitrary methods have been used for determining the time for retirements. One method was to operate the vehicle until it was worn out and required repairs, the cost of which would be prohibitive. It is evident that under this plan, satisfactory service cannot be maintained and probably in most cases false economy has been practiced.

A second method was to assign an arbitrary age limit either in years or months, or in mileage. This is obviously unsound.

A third was based entirely on the economies involved and is still in general use. The vehicles should be replaced when

the operating cost, including consideration of the loss of time due to failures and possible interruptions of the service of some department, will continue to be more than the cost of operation of a new vehicle, including the increased depreciation.

Modern Considerations Also Govern—

But the problem of replacements, at least in regard to assignment, is much more significant. On some assignments, appearance of the vehicle may be the criterion; on another, it may be comfort; on a third ease of handling; on another, vibration and rattles; on another lack of power; and so on. On the other hand, an old type of vehicle may become extremely unpopular with the employees, and the elimination of this attitude is an intangible reason for keeping the motor vehicles right up-to-date.

Other important considerations in determining the time for replacement are the advantages to be gained from modern automotive engineering. The improved designs of vehicles contain less weight, are capable of developing more speed with a greater degree of safety, are more flexible in traffic and are equipped with accessories which should lengthen the life of the parts, or reduce the cost of repair.

How Others May Help—

In the foregoing, an attempt has been made to point out some of the intricacies in the selection and assignment of motor vehicles and to show how necessary it is for the transportation men to work shoulder to shoulder with members of other operating departments, in order that the most economical transportation service may be rendered with a minimum of interruptions and complaints. In this connection, a certain amount of indulgence must be asked for because it is out of all reason to provide every operator with a new vehicle every year or two. But an efficient transportation department will seek the recommendations and specifications of the department using the unit and strive to fulfill its requirements. It must also be remembered that in some instances the point of view of the using department may be too confined to obtain the true perspective of motor fleet operation and the judgment of the transportation superintendent should be accepted when the best interests of the utility are concerned.

Let's all work together to the end that the maximum return on the investment in motor vehicular equipment may be enjoyed!

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*Power Devices**

Almost everyone is interested in one way or another in labor saving devices. Despite the recent economic depression which resulted in a considerable surplus of labor, the forward march of progress in the development of mechanical means to eliminate manual labor will continue and the conditions may as well be faced squarely. Changes and adjustments of routine must be made in all lines of endeavor to meet the modern trends. The increasing adoption of labor saving devices actually results in a breaking down of the lines of demarcation between various departments of modern business institutions, among which public utilities hold prominent positions. The dependence of each part on the others to produce the successful operation of the whole becomes more strikingly evident as results of brainwork replace brawn.

CONCURRENTLY with the development of the motor vehicle, the use of its mobile power plant has been rapidly extended to drive tools and auxiliary apparatus which lessen the work required in performing the tasks at the locations to which the vehicle is moved. The committee of the Transportation Section which was appointed to study the various aspects of the labor saving developments considered the assignment of such value that a general survey of the devices in established use was undertaken and a valuable collection of photographs and drawings illustrating the apparatus was assembled. In dealing with the ramifications of power applications, it was necessary to differentiate between tools driven by independent sources of power and auxiliary appliances driven by the engine of the motor vehicle. It is the latter which increase the usefulness of the transportation units and offer to the operating departments the possibilities of gaining marked economies.

Advantages of Power Devices

Not only do the auxiliaries actually reduce the man power required to perform the work but they usually reduce the time element, thereby bettering the continuity of service and, in many instances, eliminate or reduce the inherent hazards of accident. In some cases, other risks are introduced but these are mostly mechanical and may be eliminated with suitable guards.

Summary of Power Devices

Among the devices in more or less universal use are the following:

Single drum winches, with wire rope or cable for loading and unloading poles, pulling in underground cables, stretching line wire and general pulling operations. By means of a detachable reel, the winch shaft may also be utilized for coiling old line wires as they are retired from service.

Capstans or niggerheads, attached to winch shaft, for pulling or lifting by means of rope snubbed around them.

Cranes or derricks, for setting poles, transformers, etc. It is possible, by installing double drum winches, to operate boom type cranes, trimming the boom with a line from one drum while hoisting with the cable from the second. In selecting any auxiliary apparatus, the dead weight should be taken into consideration and kept at the minimum. Derricks which are surprisingly light for their lifting capacity may be fabricated from seamless tubing of special steels.

Pumps, for cleaning manholes or trenches of water.

Blowers, for purging manholes of foul air.

Air compressors, for operation of air tools, and washing insulators.

Electric generators for arc welding, for operating portable electric tools, for general or flood lighting at isolated locations.

Ladders or towers, for street light maintenance and tree trimming.

Fire fighting apparatus, for protection of pole lines.

In addition many applications meeting special needs have been developed.

Justification of Rental Rates

The addition of the labor saving devices does, admittedly, introduce numerous items of associated expense. There is an increase in the capital invested; the engine is in operation for longer periods of time with resulting increases in consumption of fuel and lubricants; the engine, clutch, transmission and other parts are thereby subjected to greater wear and tear; the apparatus and appurtenances, power take-off and driving mechanism require competant maintenance. It is therefore obvious that charges for the use of a motor vehicle fitted with auxiliaries should properly be somewhat higher than that made for a vehicle of corresponding capacity without such facilities. However, any charge based solely on speedometer mileage will not be equitable and such charges should be either on an hourly basis or on a combination schedule.

A Word of Caution

Care must be exercised, however, to insure that the adoption of additional labor saving devices on a vehicle will not

* Report of committee on power devices, Technical Division, Transportation Section. F. W. McGuire, chairman. W. H. Bauer, A. E. Strong.

interfere with its principal application, i.e., transportation, or hinder the operation of more important auxiliaries, winches, for instance. In certain cases, it may be desirable to use a fast truck or bus for moving the crew and delivering light material, and fit up the heavier and slow moving truck for maximum utility on the job, or assign powered tools for that purpose.

Conclusion

In conclusion, may it be said that the field for the conserving of labor by means of power devices has by no means been exhausted, and the possibilities of realizing profit through more general and more particular use of such adaptations are almost unlimited. With this in mind, the committee has secured the approval of the executive committee of the Transportation Section of the plan to make its work permanent through the preparation of a Handbook of Power Devices. The photographs and the drawings which have been collected will form the nucleus for such work. This book will contain information on all known and practical devices, and being of loose leaf style, will be kept up to date by succeeding committees.

While a handbook of this nature will contain data of primary interest to the members of the transportation departments, at the same time it will present many suggestions for adaptation to the problems of other operating construction departments, which the officials will readily recognize. To obtain the maximum economies from power device installations will require much thought by those in charge of the operations with the view of making suggestions to the transportation department for applications or adaptations of new mechanisms, and free exchange of constructive ideas for improving existing installations. In order that these suggestions may be of benefit to the industry as a whole, some central bureau should be established for the purpose of disseminating information and eliminating the duplications of effort now occurring, and it is believed that the committee on power devices of the Transportation Section, augmented by representatives from other sections will be the most logical to function in this capacity.

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*A Compendium of Garage Buildings**

The superintendent of transportation or the person with whatever corresponding title may be designated is confronted with an intricate task when called upon to lay out a new garage building, as there are numerous major or minor details which, if not given the proper attention in advance may greatly influence the cost of operation or of improvements. The designs of garages and related structures which will be satisfactory for the housing and the servicing of such a fleet of vehicles as the power companies operate are much more complicated than the ordinary commercial garage in which only passenger cars or small trucks are stored, or even a bus garage, where the pieces of equipment are of a comparable size. Provision must be made for all classes, from small passenger cars to the large trucks with overhanging loads. With a view to providing a reference list of many of the constructional features and of assisting in making certain decisions, this abstract, based upon the experiences of certain Section members and the writings of various authors in recent publications, has been prepared.

* Report of the committee on buildings, Technical Division, Transportation Section. R. V. Dodge, Jr., chairman. F. M. Rondot, E. C. Wood.

Site

THE first natural consideration in the building of a garage should be of the location. For optimum results, the site should be selected to fit the building. Usually the contrary is the condition. Much thought should be given to the location from various points of view, for example: proximity to the central activities, grade or slope of the land, size and shape of the building desired, accessibility and cost of the real estate. As a rule, a location which will front on at least two parallel streets or on one street and a service yard will be the most satisfactory and economical, with reference to operating conditions.

Size of Building

The number of vehicles which must be parked in the building should be determined with as much accuracy as is possible, as this will govern the size of the storage area. Also the parking arrangements must be studied in order to utilize the space to the best advantage or, in other words, to obtain the lowest cost per vehicle parked. The automotive equipment should be accommodated comfortably. Unduly close crowding hampers the nightly inspections and increases the chance of damage. At least 12 in. should be allowed between small cars and from 18 to 25 in. between trucks. In parking arrangements with the vehicles at right angles to the aisles, the latter, as a rule, should be as wide as the length of the vehicle facing them. In the case of diagonal parking, they may be proportionately narrower. After the storage section is laid out, plans for the other rooms required for the repair and the service operations should be prepared and combined with that of the storage section. Ample allowances should always be made for expected growth.

General Building Features

The cost of the ground generally determines whether the building will be single or multi-storied. If economically practical, a one-story structure is preferable, as multi-storied buildings require more columns and these are always objectionable. A roof with a single span in the storage section is the most desirable and is practical up to 80 and 100 ft., as the building regulations may determine. Remember that the first cost, in this connection, may not be the last. If columns must be used, they should be spaced so as to facilitate parking. Basement storage should be avoided as far as possible, on account of the increased ventilating difficulties.

Ramps Versus Elevators

In buildings of more than one floor, some means must be provided for moving the vehicles from one floor to another, unless the topography is such that cars may enter from different streets. A selection must then be made between ramps and elevators. For various reasons, the preference leans toward ramps. Elevators are constructionally more expensive, are slower in handling the cars and are subject to breakdowns. Further choice, if ramps are selected, must be made between the "full length" type and the so-called "motoramp," which latter incorporates the staggered floor idea. Comparative figures by the developers of the latter system show approximate storage efficiencies as referred to an ideal utilization of space in a one-story building as follows:

Single floor (two aisles, four parking areas)	100 per cent
Motoramp (staggered floors)	86 per cent
Single elevator with necessary approach and cross-over areas	82 per cent
Ordinary or continuous ramp with cross-over	71 per cent

These were based on ordinary passenger car storage. The usual grade for the ramp is about 15 per cent. Another advantage claimed is that the short straight ramps afford complete visability with consequent increase in safety. For the motoramp type, one dimension of the building should be not

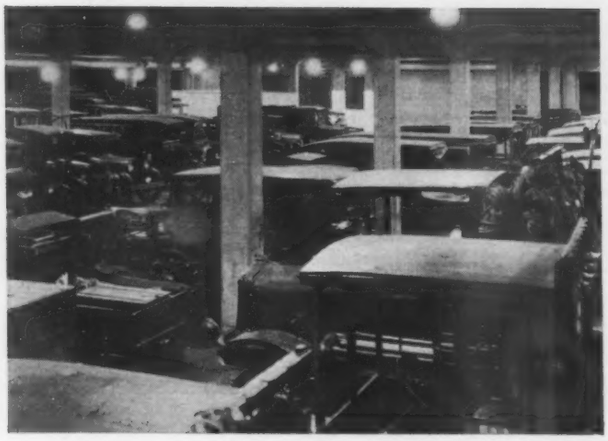

Fig. 1. View of the storage section of utility garage of reinforced concrete construction. Rolling steel doors in end and on right hand side (not shown) open onto streets, those on left hand side onto a service yard. The car washing section is seen in the center background. The section is lighted by 500 watt lamps in glassteel diffusers on approximately 20 ft. centers, giving a uniform intensity of ten foot candles.

less than 50 ft. and the other not less than 100 ft. for small cars and proportionately larger for trucks, depending on their turning radii. A recent modification of the motoramp type of building is the continuous or all-ramp garage constructed by the Consolidated Gas, Electric Light & Power Company of Baltimore.

Style

Before selecting the main building materials, the many codes governing construction should be consulted. There are insurance regulations, state restrictions and local building ordinances which must be adhered to. Buildings of "fireproof" construction are warranted even though they may not be required. In some localitiees, however, wood frame and "mill" or slow burning types may be built. Some regard for the general appearance of the building must be given. Architectural monstrosities will no longer be condoned by self-respecting communities and much good-will may be lost through the erection of a "barn-like" building.

Doors

Entrances and exits from the garage must be carefully planned. Every "live" car should face on an aisle or should be parked directly at a doorway. Each aisle should lead either directly or indirectly to a doorway. Since the maximum permissible body width on California highways is 8 ft., doorways should be not less than 10 ft. and preferably not less than 12 ft. wide. The heights of the openings will depend on the company's equipment. They should be at least 1 ft. higher than the highest cap or body. It pays to have doorways of adequate size. Due to size, fire hazard and risk of damage, wooden doors are not generally satisfactory for garage purposes. The single leaf swing doors are also impractical, due to size. Doors may be selected from the following styles: sliding, multiple leaf folding, either vertical or horizontal, or steel rolling curtains. The first two types require suitable trolley hangers and tracks. The greatest objection to the curtain type is that it cannot be fitted with sash to add to the natural lighting. Also, unless power-operated, they may be slow in opening and closing. "Fire" doors may be required at all openings and apertures. If doors be of the swinging type, they should preferably open outward and the hardware should include an automatic catch to hold the doors in the open position.

Floors

The next question to decide is the type of flooring. The building codes generally prescribe that floors must be of concrete or non-combustible materials. In addition, the material should be non absorptive of oils and should readily be cleanable. The trouble with concrete is that when it is made smooth enough for easy cleaning, it becomes dangerously slippery. Hard pavements have the objectionable feature of causing fatigue to service or repairmen. Perfection in floor coverings has not been achieved at this date. Floors should be pitched in order that water and other fluids will run into drains. These drains should be equipped with oil and sludge separators or traps, if they discharge into a sewer line. Provision should be made for the convenient cleaning out of such separators. A good plan, if continuous drains be not provided, is to place the drains in the aisles, spaced about 20 ft. on centers. Slopes to the drains should be at least ¼ in. per ft.

Windows and Skylights

A maximum amount of daylight is nearly always desirable and should be provided by means of windows, sash in doors, and skylights.

Fire Walls and Sprinklers

The floor area between fire walls in large garages will probably be limited by insurance regulations. The permissible maximum size in garages equipped with a standard system of automatic sprinklers is practically double that of an unsprinklered building. Buildings over two stories in height generally must be protected with sprinklers. It may often be desirable to reduce the areas considerably below that allowed in the regulations in order to limit the amount of damage to a fleet with consequent interruption to service. In steel buildings, the cost of the sprinkler system may be somewhat offset by the saving possible through the permitted omission of the "fire-proofing" of the structural steel roof supports, otherwise required.

Ventilation

More and more attention is being paid to secure adequate ventilation in all parts of garage buildings. Do not lose sight of the fact that there may be flammable vapors and poisonous gasses which are heavier than air. Natural ventilation may be sufficient if it be practicable to keep windows or louvres open at all times. An adopted rule for storage sections is that a positive circulation of at least 1 cu.ft. of fresh air be provided for each square foot of floor area. This may be accomplished by means of either "forced" or exhaust

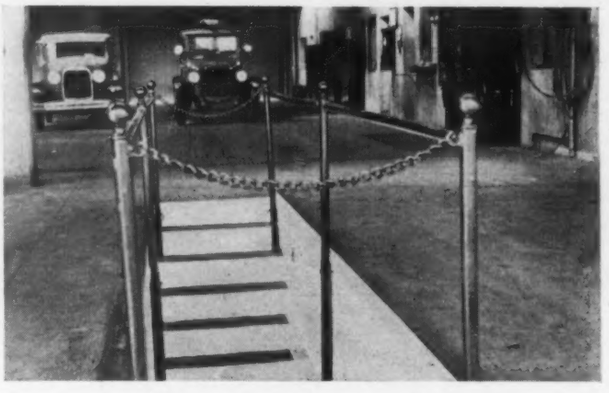

Fig. 2. The servicing pit in the storage section of the garage is protected with a pipe railing of novel construction. The walls of the pit are painted white and contain lamps in niches or recesses to furnish illumination.

blower systems or both. Exhaust openings, owing to the nature of the mixtures, should be placed not more than 2 ft. above the floor and should be spaced not more than 50 ft. apart. Inlet openings should be at such a height that the air will be discharged over the tops of the vehicles. Certain modifications of this practice may be required by local ordinances. In the main, it is essential that the amount of carbon monoxide gas be kept below two parts in 10,000. A concentration of two parts in 10,000 will probably produce headaches and 50 to 60 parts will be fatal. The ordinary four-cylinder motor discharges from 1 to 1½ cu.ft. of carbon monoxide per minute from which calculations of the pollution may be made. Unventilated pockets where accumulations of exhaust gases may occur, should be avoided. The ventilation of certain spaces will be taken up later.

Artificial Lighting

Ever since the advent of the "gas-filled" or Type "C" Mazda lamp, there has been a crying need for protection of the eyesight from the extreme brilliancy of the filament, but this necessity has not always been recognized. Bare lamps with clear glass bulbs should never be used, unless the lamps are entirely out of the range of vision. In paraphrase, illumination, not light should be supplied. Since time rapidly becoming immemorial, it has been the practice to skimp on electrical wiring and fixtures, but it is beginning to be realized that efficient night lighting must be provided and "efficient" means light free from glare, with absence of sharp shadows, as well as with intensities up to modern standards. Practically this means that some sort of diffusing globes must be supplied. Good lighting pays.

Heating

Even in the balmiest sections of California, heat is needed during some portions of the year in offices, shops and storerooms. In the garage and repair shops, the open flame type of heaters should not be permitted on account of the fire and explosion hazards. Steam and hot water are admittedly the best heating media. But remember that radiators under work benches create unpleasant working conditions and are fast becoming abandoned in favor of space heaters or coils through which air is driven by a fan, creating a wide and even distribution of heat and at the same time reducing installation cost for equivalent radiation. In no event should the temperature be permitted to fall much below 40 deg. F.

Pits

So much for the structural generalities for the present. Now for the question of pits, both service and repair. Until

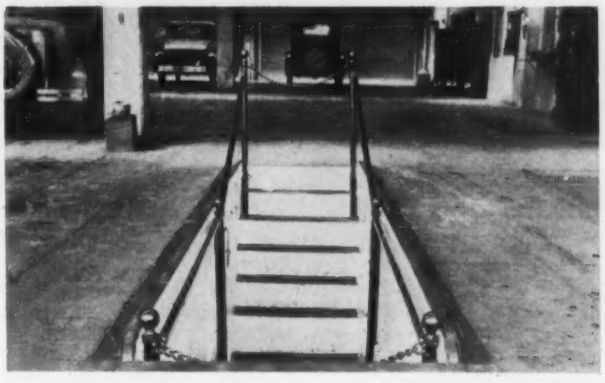

Fig. 3. The railing is composed of posts which may be dropped into the sockets, each independently of the others. Only four posts need be dropped, as shown, if it be not necessary for the car to pass completely over the pit.

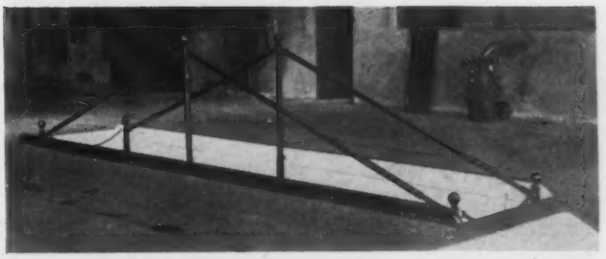

Fig. 4. This picture shows how the flexibility is obtained. The rails consist of two pipes, one sliding inside the other. Portions of the inner pipes can be seen next to posts at right hand side.

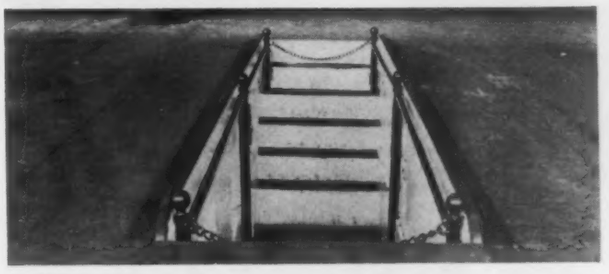

Fig. 5. Any car or truck may be driven over the pit when all posts are dropped. The pins which are inserted through holes in the posts and sockets when the railings are up, can be seen attached to the sockets by short chains.

such time as some safe and reliable means of lifting the heaviest trucks is perfected, we shall probably be called upon to consider pits. Pits, as a rule, are difficult to keep clean, require special ventilation and introduce hazards of falls, therefore are more or less a necessary evil. Pits should be of masonry or concrete construction and should be protected with railings. (See the May 15, 1929, edition of *Electrical West* for an article on a drop type of railing for service pits.) Special ventilation should be furnished for every pit by a mechanical system independent of the main one. Where a battery of pits is required, it is best to have them connect into a transverse pit at the wall end. This eliminates a great deal of climbing in and out of the pits and facilitates the ventilation. Permanent lights should be provided in the pit walls with special fixtures for diffusing the light and protecting the lamps. Tool ledges and work benches are often desirable. Numerous electric convenience outlets should be included in the layout. Also provide means for easily cleaning out the pit. An English writer recommends white tile walls in the pits, both as an aid to illumination and as being easily kept clean. Any reasonable expenditure which will produce cleaner pits is warranted. Tile may also be used to advantage as wainscoting in the garage and repair shops.

Washracks

Every garage headquarters should be equipped for washing and cleaning the chassis and uppers for running service and in overhaul work. In smaller garages, the cars and trucks may be washed in their parking places, but, generally speaking, a separate enclosure, properly equipped for cleaning, gives better results. In the larger garages, washracks fitted for progressive cleaning operations may be demanded. In these instances, the gravity method of moving cars, with troughs for the wheels, may expedite the work. In making provisions for washracks, also consider the following:

Hoists
Trestles or runways
Tanks for cleansing solutions
Cleanser storage

Heating media—steam boilers
High pressure water pumps
Overhead washers
Special illumination of high intensity with minimum amount of glare
Vacuum cleaning apparatus, either stationary machines with piping and outlets or portable outfits
Drainage
Waterproofing
Cabinets for storage of hose, boots, sponges, etc.

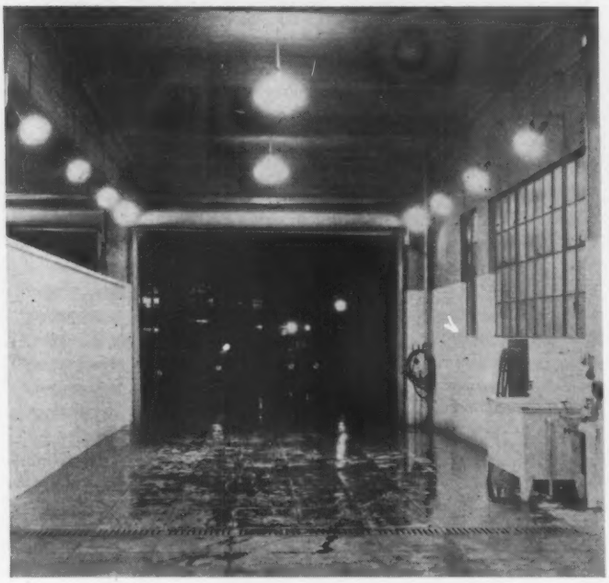

Fig. 6. In addition to the overhead fixtures, the car washing room is made brilliant by means of projecting fixtures on the sides, increasing the intensity of illumination to 25 foot candles. The tank at the right contains cleaning solution which is heated by live steam. Continuous gutters with cast iron grating provide for drainage.

Referring to heating media, no open flames should be permitted in the garage sections. That is, if boilers, furnaces, etc., are to be installed they should be located in separate rooms or structures. The walls and floor of the washrack should be of such construction that they may be easily and effectively cleaned and should be waterproofed.

Repair Shops

In addition to the points previously set forth which are applicable to the shops section in general, a number of other features will be mentioned. Suitable means should be provided for performing all overhaul and repair operations which are not "farmed out." No attempt will be made to list the machine tools, as recommendation along these lines should properly emanate from the maintenance division of this section. Pits, hoists or cranes or all of them may be required and after selection, may require modification of details in the architecture of the building. Substantial work benches should be provided in sufficient number to care for hand work. Regulations generally specify, and correctly so, that repair sections should be separated from the storage section by a non-combustible wall. If the engines are to be tested or "run in" in the shop, it is advisable to provide ducts which can be connected to the muffler to lead the exhaust gases out of doors directly.

Battery Room

Separate rooms should be arranged for in which to charge storage batteries and make electrical tests. In addition to the structural details required for whatever charging apparatus may be decided upon, hoods with means for ventilating may be needed over the charging bench, to remove the vapors. If acids are used, safe storage and means of handling should be incorporated. The plumbing and fixtures should be "acid-proof," also the bench tops where batteries may be repaired. Suitable benches for making electrical repairs and tests will also be required.

Tire Repair Shops

In the tire repair room, provide for the vulcanizing, moulding, tire stripping and tube testing apparatus.

Other Shops

In garages for the larger fleets, it may be the practice to handle all repair work needed, not only on the motor but on the chassis, bodies, etc., in which case layouts for carpenter, blacksmith, machine, upholstery, tin or sheet metal and paint shops must be included in the plans. No attempt is made to set forth any details of these except some for the latter, which follow:

Paint Shops—

The now almost universal use of lacquer finishes for automobiles has altered and made more complicated the layout for paint shops. The vapors produced in spraying lacquers are inflammable and explosive and heavy. These must be reckoned with. Paint shops should be isolated from garage or other shop rooms, at least by fireproof walls. The usual methods of applying lacquers are by means of air guns with the lacquer either in holders attached to the guns or in a pressure tank from which it is led through a hose to the gun. In very large installations the lacquers and primers may be piped to outlets from a central supply tank. It is best to limit the quantity of lacquers, thinners and paints and oils stored in the shop. Special lighting units of the vapor proof variety are required in safe practice. Ample illumination is essential for successful spray coating and glare must be avoided. The floors should slope to drains.

The shop should be equipped with a sprinkler system. Ventilation will play an increasingly important part in reducing explosion hazards and protecting the health of the workers and the regulations, which are becoming more stringent, should be carefully studied. If specific volumetric flows of air are not prescribed, the number of air changes should be at least 30 per hour, but each case should be studied individually. In certain rules, definite air velocities are set forth in lieu of air changes. As positive ventilation is always required, specially designed exhaust systems are called for. They may be of the direct or the indirect type. The former has a fan in the exhaust duct, whereas the latter utilizes the ejector principle, by discharging air from a blower into the main duct through a smaller duct, properly directed. All ducts should be of non-combustible material and should be equipped with baffles to separate the solids. Both the ducts and the baffles should be readily cleanable. For vapors heavier than air, the exhaust openings should be near the floor. All surfaces should be thoroughly wetted down for safety before cleaning and for this purpose water connections should be supplied in the shop. If paint be used for fine finishes, a dust-proof room or cabinet will be needed, on account of the slow drying characteristics.

Prepainting Equipment—

Difficulties have been experienced in neutralizing chemical paint removers and some companies have abandoned their use in favor of paint burning or sandblasting. The design of shops for such purposes entails special considerations. Where paints or lacquers are used in large quantities, isolated compartments for "mixing" rooms should be included in the layout.

Stock and Tool Rooms—

Convenient to the shops should be located the stock and tool rooms. The size of the room will, of course, be gov-

erned by the needs of the shops which they serve. Sufficient counters, window shelves, bins and racks should be provided for. In general, steel bins are more desirable than wooden as they reduce the five hazards, gain a little storage space (10 per cent more) and are more easily altered and cleaned Numerous special sections and racks will be needed to store conveniently many stock parts.

Washrooms

In these days washrooms demand particular planning, both as to arrangement and fixtures. Floors should be water-proof and should slope toward drains. There are many types of stall partitions from which a selection must be made.

Fig. 7. Adjoining the storage section is the repair shop. Note the removable boards over the pits, overhead tramrail with trolleys and chain hoists and illumination by glassteel diffusers.

Likewise there are numerous types of wash basins or their equivalents on the market. In addition to washing facilities, toilets and urinals, all modern washrooms should be fitted with shower baths. Unless some central supply system can be tapped, hot water heaters will be needed. In some liquid soap dispensing systems, if adopted, special built-in features must be taken care of. Also some towel or soap containers, waste receptacles, etc., may demand special construction. Attention should be paid to secure proper heating and ventilation. Drinking fountains should not be overlooked, not only in the washroom, but throughout the plant.

Recreation and Locker Rooms—

In order to reduce the expense of labor turn-over, comfortable quarters in which the employees may eat their lunches and spend their rest periods are needed. These should be clean, cheerful and, during the cold weather, heated. Appropriate furniture should be supplied. Locker rooms, fitted with individual lockers for clothes changes, safe keeping of tools, etc., have become practically necessities. Steel lockers are preferred to wooden on account of the reduction in fire hazard and for sanitary reasons. The lockers may be of the built-in variety. Other furnishings required are benches, or chairs, and mirrors. Positive ventilation in these rooms is desirable.

Gasoline and Oil Stations

Associated with garage operations must be storerooms for oils and gasoline filling facilities. The inflammable nature of these supplies dictates a separate and fireproof building for the maximum protection. Oil rooms should be provided with ventilators with intakes near the floor level. Much could be written on this subject but layouts and planning service can be obtained from the manufacturers of gasoline and oil storing equipment. It is the usual practice to store gasoline in underground tanks from which it is pumped by hand, air pressure or motor-driven pumps. In conjunction with the latter, sentries with dial indicators are rapidly becoming popular due to the positive and quick filling rate, remote control possibilities, and the facility and accuracy of measurement. Oil may be similarly stored underground, but it is prevailing practice to keep it in surface tanks fitted with measuring pumps. Cranes or monorails may be needed in the oil room to expedite the handling of drums. Reclaiming outfits for crankcase oils have appeared on the market and those distilling or refining the oil are practical. If the quantities and quality of the motor oils removed are sufficient, the installation of the reclaiming apparatus may be warranted and the necessary space and details must be taken care of. Greasing systems, also, may require special structural features.

Offices

No particular features of the office rooms will be treated. Suffice it to say that sufficient space should be allotted and the required partitions indicated.

Piping

Returning now to the generalities, keep in mind the necessity of providing for all the pipe lines which are needed at the present time or may be anticipated for future use. Among these are air and water lines with outlets throughout the working sections on not more than 40-ft. centers; drain or waste lines; steam and condensate returns; possibly gas, vacuum, grease, oil, paint and other special fluid pipe lines. Hot water lines rapidly corrode the ordinary steel pipe, therefore brass or special alloyed steel or cast iron pipe is recommended. Make all pipe lines accessible for repairs, as far as possible.

Conduits and Wiring

Conduits for the wiring for lighting fixtures, plug receptacles and power circuits should all be of more than ample size as it is well to provide for future loading. Convenience receptacles should be placed at strategic points. Chases in the walls are usually required for switch panels and should be located where they will be most convenient. Conduits may also be required for telephones and call or signal circuits.

Floor Coverings

Supplementing the previous paragraph on "Floors," a study of floor coverings will be necessary to secure the best results in each department. In the shop, the desirable properties are: fire-proof, non-absorptive of oils, readily cleanable and non-fatiguing, as well as durable. In the battery room, floors which will resist acids or alkalies may be desirable. Washroom floors should be water-proof and should not be slippery. Floor coverings in the offices should be resilient and sound absorptive. In the stockrooms, the coverings must resist the trucking and other hard usage. There are many coverings in the market from which to make the selections.

Special Building Features

Except in one story buildings, there will be need for stairways, also, possibly, truck, freight or passenger elevators. These will materially affect the plans for the biulding, to a degree depending upon the types selected.

Special Apparatus

There follows a list of some of the special apparatus which may require special treatment in the building details:

Air compressors.
Water pumps.
Hydraulic hoists.
Cranes, monorail supports.
Scales
Brake testers.
Wheel alignment indicators and adusting devices.
Shop tool equipment.

Transfer tables, conveyors, turntables.
Troughs, wheel guides.
Headlight adjusting equipment.

Fire Protection

Building ordinances generally specify the number and kind of fire extinguishers which shall be furnished. In the absence of such specifications, a reasonable rule is one 2½-gal. foam type for each 2,500 sq.ft. of floor area and, in addition, one carbon tetrachloride extinguisher of not less than one quart size and one pail or metal tub of 8 gal. capacity for sand. The smaller types of extinguishers may not require any provisions in the building construction. Sprinkler systems have been previously mentioned and in multi-storied buildings, standpipes for fire department use will probably be required. Private stand pipes with outlet valves with hose and nozzle connected may be specified or desired, and if local water pressures are insufficient, fire pumps and tanks may be demanded. In tall buildings, fire escapes will be required.

Signs

Significant signs should be displayed in prominent locations to emphasize rules, issue warnings, direct traffic, etc. Plain signs may not need any special consideration, as far as the building design is concerned, but bulletin boards and directories may.

Concluding Remarks

The foregoing paragraphs have, without doubt, demonstrated most conclusively that the planning of even a small garage building entails much thought if a thoroughly practical structure be insisted upon. This paper is presented with the thought that possibly reminders of some features which might otherwise have been overlooked may be herein contained.

Continuity

It is believed that there are almost unlimited opportunities for the buildings committee of this Section to assist the industry, by studying the various building details peculiar to transportation department uses and by rendering reports of its findings and making suggestions for improvements. It may also serve by preparing designs of layouts of typical buildings, efficiently planned, which will serve as guides for future construction.

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*Power Tools**

This committee conducted informal discussions at the Section meetings and prepared preliminary plans for the continuance of the work the coming year, covering the improved design and new makes of pole-hole diggers, the equipping of tractors with rigging attachments, cranes and winches for field work.

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* Report of power tools committee, Technical Division, Transportation Section. W. H. Fairbanks, chairman. L. A. Savage.

MAINTENANCE DIVISION REPORTS[2]

Repairs[3]

This committee discussed repair-shop practices and methods of maintenance and general overhaul repairs, field repairs and service work to motor vehicles. This committee recommends the adoption of a system of making monthly inspections of motor vehicles, and automotive power tools, and periodic inspections of trailers, special equipment and shop equipment.

Materials[4]

Considerable work was accomplished by this committee in the way of special papers on tires, lubrication methods and materials, reclamation of motor oil, fuel, etc., which were discussed at great length at the Section meetings. The content of the subject matter was such, however, that it was not believed practical to prepare these papers for publication, although Section members were furnished copies of these papers for their own reference and guidance.

The materials used in different types of line truck and other vehicle bodies supplies the basis for considerable work which will be taken up the coming year.

Accessories[5]

This committee conducted informal discussions at Section meetings and prepared a list of desirable accessories for use on motor vehicles.

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[2] V. W. Dennis, Pacific Telephone and Telegraph Company, chairman.
Los Angeles Gas and Electric Corporation: J. B. Prewett.
San Diego Consolidated Gas & Electric Company: G. D. Brown, F. M. Sherrill, C. D. Weiss.
San Joaquin Light & Power Corporation: F. C. Foy, S. E. Hickman.
Southern California Edison Company: F. M. Rondot.
Southern Sierras Power Company, C. H. Gray.
Tucson Gas, Electric Light & Power Comany: R. V. Sanford.

[3] Report of repairs committee, Maintenance Division, Transportation Section. J. B. Prewett, chairman. G. D. Brown, R. V. Sanford.

[4] Report of materials committee, Maintenance Division, Transportation Section. F. M. Rondot, chairman. S. E. Hickman.

[5] Report of accessories committee, Maintenance Division, Transportation Section. C. H. Gray, chairman. F. M. Sherrill.

*Aesthetics in Motor Vehicles as a Business Asset**

Standards of equipment and of maintenance reflect the general attitude of the management operating a fleet of motor vehicles on the public thoroughfares and highways. In this treatise will be pointed out some of the effects of slovenliness and the benefits accruing from a proper policy of good design, selection and high standards of maintenance.

WHAT would you think of a large merchandising institution if, after you had made a purchase to be delivered, the package should be brought to your door in a ramshackle conveyance which had not been painted since nineteen umpty-ump? Undoubtedly the reputation of that store would be lowered in your estimation. Do you think that your customers, the consumers of electric energy, will overlook and pardon the errors of omission or commission in the care of your vehicles that you would condemn in others? Nine-to-one they will be even more critical.

Benefits

Therefore it behooves those in charge of transportation to make an inspection, so to speak, of the members of their vehicular households and take steps to improve the general appearances of equipment, wherever needed. It will be found that with reasonable expenditures to secure neatness, the good-will of the public will be augmented and favorable comment will result. Those who have devoted some thought and effort towards improving the looks of their vehicles have found that they have received sundry rewards other than this increment of good-will, these being increased efficiency

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* Report of appearances committee, Maintenance Division, Transportation Section. C. D. Weiss, chairman. F. C. Foy.

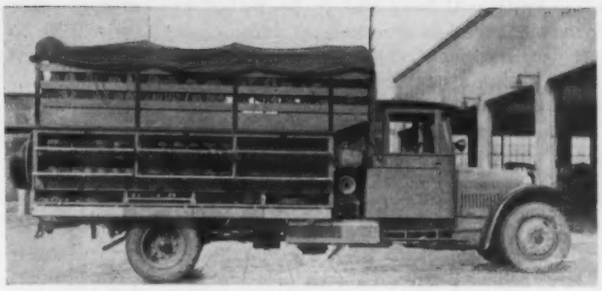

Fig. 1. In attempting to improve the looks of line trucks, it was found that much more convenient stowage of materials could be obtained. This photograph shows the arrangement of compartments in recent body construction.

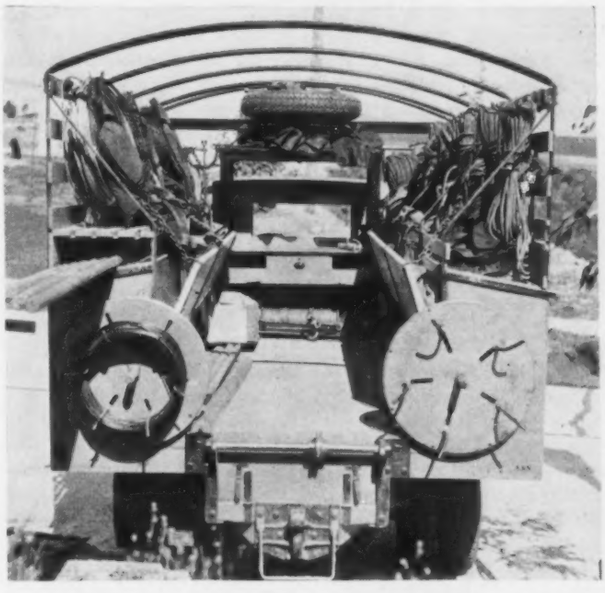

Fig. 2. The end view illustrates how ropes and wire are carried. The boards on the sides can be dropped down to form seats for the crew.

by having a place for everything, reduced deterioration, increased safety and comfort and the benefits to be derived from a developed sense of pride of the employees operating the equipment.

A careless or selfish management will not give much thought to the looks of its vehicles. Such a concern will soon be judged by the public as either being in straitened circumstances or being operated penuriously with little or no civic pride. Forlorn appearances also indicate lack of systematic maintenance. This, in turn, means shorter life and eventually greater operating costs. From which, it may be deduced that it is false economy to neglect the "outward appearance."

Indiscriminate Stowage

A large part of the "artistic offense" may be caused by the manner in which materials are piled or just "heaped" onto the vehicle. Dangling articles, in particular, create an unharmonious aspect. Not only do such poor housekeeping methods indicate a lack of proper supervision, but they generally mean a distinct monetary loss in time spent in looking for something.

Felonies

A few specific violations of the aesthetic code are now mentioned: boxes or material on running boards, weather-beaten paint, tarnished or rusted plated parts, broken glass, torn tops or side-curtains, dented or crumpled metal work, broken boxes or lids, doors or sideboards in bad repair. And there are others. In the stowage, coils of ropes, coils of wire or hose, water or tool bags and the like must be watched particularly and suitable racks should be provided which will hold the articles neatly and conveniently. While it is admitted that the trucks of the purveyors of electrical energy are not, per se, things of beauty, their appearance generally can be improved with a little care and forethought without sacrificing their utilitarian features.

How to Obtain the Results

Among the ways and means of accomplishing the desired betterments are: selection, design, cleaning, and maintenance.

Selection.—This refers to the original purchase of equipment. Modernity always should be sought in hood and cab lines, wheels, bumpers, etc. Even the tires exert an unmistakable influence. Select good-looking equipment.

Design.—Referring to trucks, it is the usual practice to have the bodies, box equipment, racks, cranes, and other super-chassis paraphernalia made to order. The design of the added equipment should be congruous with the chassis and cab. Body, box, and rack arrangement control the stowage of materials and, as far as possible, a place should be provided for everything that must be carried. Of course,

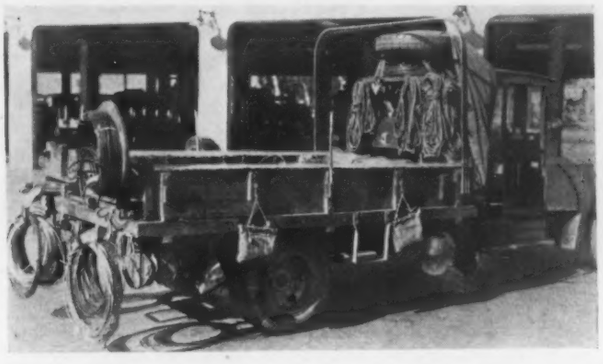

Fig. 3. The practice of carrying coils of wire, water bags, snatch blocks, etc., on outside or under trucks is detrimental to good looks. To avoid this, was one of the reasons for the development of the new type of body.

Fig. 4. Another view of an old style body, with no place provided in which to carry wire.

"design" of passenger cars and standard light trucks will be included under "selection."

Washing.—All vehicles require frequent washing. Nothing is so detrimental to an otherwise trim-looking outfit as mud, grime and other stains of the road. Keep them washed. Polish frequently the parts requiring that treatment.

Maintenance.—Under this heading the outstanding item is painting. Paints and lacquers are wonderful hiding media. The garage superintendent of a large New York department store writes: "Paint and appearance, however, usually are the factors that cause the vehicle to be withdrawn from service." He has the right "slant."

How often shall our vehicles be repainted? Query the transportation superintendents. The answer is—as often as is necessary to keep them up to a meticulous standard of appearance. Service is a governing item. On easy assignments once in two years may be satisfactory. Where the operating conditions are highly unfavorable or severe, perhaps two or even three repaintings may be required in one year. Before sending a vehicle to the paint shop, all metal, glass and wood work should be repaired or, where necessary, replaced, upholstery, tops, and curtains renewed if needed and chassis repairs attended to. Some system of periodic inspection should be placed in effect in order to make certain that all equipment is kept in A-1 condition. Inspectors should be trained to watch carefully for cars requiring repainting, as the overhaul criterion.

Paints Versus Lacquers

Pyroxylin or lacquer finishes have now been developed to such an extent that they have decided advantages over oil finishes on metal surfaces. Two of these are: durability and quick-drying properties, the latter reducing the time out of service. For the wood work, paints and enamels still have the preference. In the selection of lacquers as well as of paints, it is advisable to make tests to determine the suitability of the material for the operating conditions.

Colorful hues still predominate in the field of automobile finishes, although there has been some tendency recently to revert to staid black finish for passenger cars. In adopting a color system for a fleet of vehicles, combinations which will be harmonious should be selected. Probably it will be well to avoid strikingly flashy colors, as not producing a favorable impression upon the conservative majority of consumers.

Insignia

Much debate has centered upon the premise "shall a public service corporation display its name and trade mark or coat-of-arms?" Judgment should be in favor of the affirmative, because, with properly applied maintenance such vehicles demonstrate that the owner has a sense of pride for appearance in the community which it serves and such owners should be identified. As hand lettering and hand painting of insignia will be found to be rather expensive, a more economical method for fleets of considerable size will be to use decalcomania transfers. These transfers, if the design of the insignia permits, can add a dash of color which may break the monotony of a solid color. Transfers should be carefully proportioned to the areas in which they are to be placed and it may be necessary to adopt several sizes as standards. If possible, the transfers should be applied on parts where protection from rubs and scratches will be afforded.

Advertising

It is believed to be a good rule to limit the use of advertising matter on cars or trucks. If any be permitted, it should be either of a permanent nature, as lettering on the sides of a panel job, or in neat frames. Banners and placards almost invariably detract from appearances. The company's name and insignia on a well-kept truck should be advertising enough.

Co-operation

Co-operate! It's an overworked word, so perhaps you have heard it before. But in maintaining appearance, there are unlimited opportunities for the members of other operating departments to assist the transportation department. The driver of a vehicle may not be under the direct jurisdiction of the latter, but how he keeps his material stock, how he drives, how he dresses and his poise will impress the laymen or, at least, many of them. The line foreman and his crew also can help greatly by keeping things "ship shape" and avoiding practices which will detract from the looks of the crew truck, particularly in keeping coils of wire, ropes, tie wires, etc., from hanging on the outside.

Audible Defects

And here's more food for thought. Faulty appearances of automotive equipment may be audible as well as visual. In a recent popular recording, a chap said "the movies used to hurt my eyes, now they hurt my ears." In a like comparison the noise from poorly adjusted motors or gears, rattling bodies, hoods, etc., may be just as much a disturbing influence on the streets as are dilapidated looks. Explosions in the mufflers and squeaky brakes may and do jar on the nerves of many persons, with resulting ill-feeling toward the owner of the malefactor. With proper care, these annoyances may be minimized.

In reiteration, look at your equipment! Your cars, trucks, automotive tool equipment and trailers in reality are traveling mirrors, reflecting the character of your concern and measuring the quality of service which you are prepared to render. They can be made mute, but poignantly effective advertisements of courteous and considerate treatment. Dividends, both tangible and intangible, which will accrue are yours for the effort. It's up to YOU.

ACCOUNTING DIVISION REPORTS[2]

*Records**

THIS committee obtained from member companies all the transportation forms and records used by them, keeping three sets of the collected forms on file for reference.

After much study it was found that the forms varied so greatly for the same kind of work that it was impossible to make a presentation of a complete set-up until all members of the section had had an opportunity to review the illustrated set-up and make recommendations and suggestions.

The committee found that work on forms and records could be carried on more intelligently by classifying the forms into three divisions: Accounting, Maintenance, and Operation. Under these heads the forms have been segregated and the study of each class of forms and records is being made.

It is believed that there is sufficient value to the study of simple and efficient forms and records to warrant very serious consideration of the subject. Therefore it is recommended that the work of this committee be carried over

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[2] J. M. Wainscoat, San Joaquin Light & Power Corporation, chairman.
San Diego Consolidated Gas & Electric Company: W. E. Frazer.
Sierra Pacific Power Company: E. D. Brown.
Southern California Edison Company: H. D. Tisdale.
Southern Sierras Power Company: J. S. Bordwell.

* Report of records committee, Accounting Division, Transportation Section. J. M. Wainscoat, chairman.

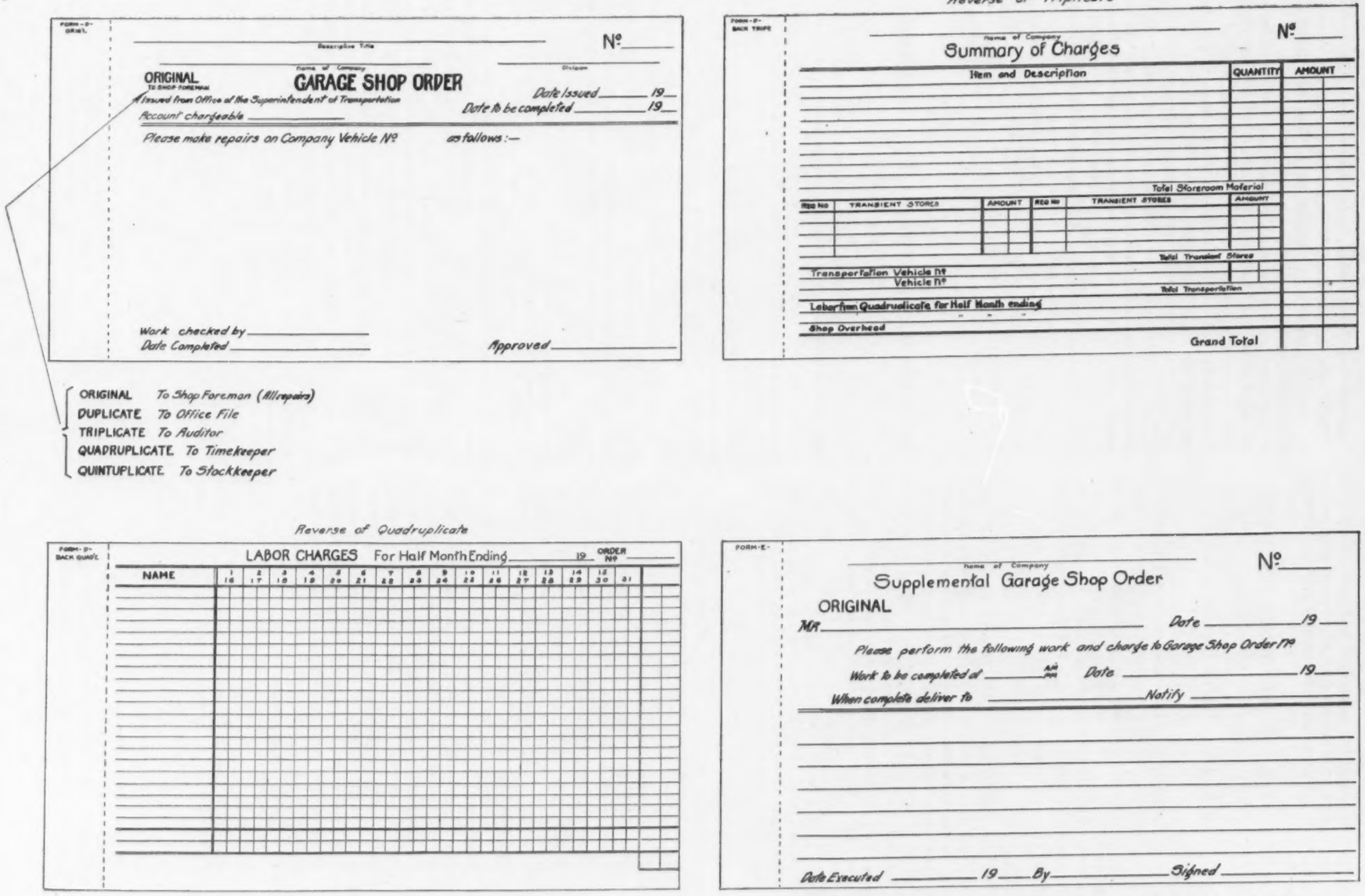

Fig. 1. Garage shop order forms.

for next year to enable the committee to prepare a comprehensive report, with an illustrated set of recommended necessary forms and records to control properly any size of fleet of motor vehicles.

A partial report is made here covering a garage shop order system.

Garage Shop Order System[1]

Garage Shop Order, Form D—

This form, numbered serially and in quintuplicate, is issued from the office of the transportation superintendent to the general garage foreman for all repairs to automotive equipment.

The order, when issued, carries the date, charge account number, date to be completed, and a full description of work to be executed.

Original—

The original copy is sent to the general garage foreman where it is filed in a visible order rack, where it remains until the completion of the work. To this garage shop order number the mechanics charge all labor and material expended in making repairs as listed thereon, or any other repairs encountered and not foreseen at the time the order was issued. All additional repairs are noted either on the face or reverse of the original order. Upon completion of repairs the mechanic responsible for the work signs the order in the space "Work checked by," and inserts the date the work is completed. The garage foreman then signs the order in the space "Approved," and forwards the order to the transportation superintendent's office.

Duplicate—

The duplicate copy of garage shop order is filed in loose-leaf book in the transportation superintendent's office and is used for reference and as an aid in checking the progress of the work. This duplicate copy remains in the superintendent's office until the completed original copy is sent in by the garage foreman. It then is removed and, together with the original, is forwarded to the accounting department. (Accounting work may or may not be under the supervision of the transportation superintendent.) This serves as their notification that all work has been completed and they may complete the accounting of the order.

Triplicate—

The triplicate copy is forwarded to the accounting department as soon as the order is issued. From this copy the accounting department makes up a 7½ x 9¼-in. folder on which is typed the garage shop order number, date issued, charge account number and a brief description of the work authorized. On the reverse side of this triplicate the accounting department, upon completion of the work, types the final summary of labor and material charges which have been accumulated in the folder, and it is forwarded then to the general office for final accounting.

Quadruplicate—

The quadruplicate copy is forwarded along with the triplicate to the accounting department, upon the reverse side of which all labor charge against the order is posted daily, showing mechanics' names and amount of time (in dollars and cents) expended on the order.

Quintuplicate—

Quintuplicate copy is forwarded to the garage stock keeper where it is filed and referred to as an aid in making charges for materials.

Supplemental Garage Shop Order, Form E—

This form, in duplicate, is issued by the garage foreman to authorize repairs to vehicles by a shop not under his supervision.

This form carries the same garage shop order number as the original garage shop order on which the garage repair shop is executing repair work. The original copy of the supplemental order is forwarded to the foreman of the shop executing the work, and duplicate is filed in the transportation superintendent's office. The duplicate supplemental order is kept on file until the completed original supplemental garage shop order is received, then the duplicate supplemental order is removed and the original supplemental order is forwarded to the accounting department to be filed in folder of garage shop order. All labor and material expended on these supplemental orders are accumulated in the garage shop order folder along with all other data pertaining to that particular garage shop order, and are included in the final summary of charges.

[1] Prepared for the records committee.

*Individual vs. Group Cost Accounting Systems**

Upon entering into this discussion of costs of operating and maintaining automotive equipment, this committee realizes that most of us have in the past done no small amount of theorizing. Having had the benefit of practical theories, the committee will endeavor to concentrate on actual experience so that we may draw our conclusions from past automotive equipment performances and facts of record, combined with standard practices.

With this thought in mind, a letter of inquiry was addressed to members of the Transportation Section, asking for opinions on the subject. Out of seventeen requests, ten replies were received, and this study is based upon these expressed opinions which without exception appear to be founded upon the experience of the various member companies.

IN considering the advisability of maintaining cost records for each individual car or by groups of similar makes and types of equipment, we must study the practical usage through which the results will be made to function and whether or not the results in either case justify the expense of compiling such cost records must be carefully studied.

Of the ten replies to this questionnaire, seven are favorable to the compiling of costs for individual cars, one for costs by groups of equipment, and two provisional declarations. There are quoted herewith the statements favoring the individual unit cost plan, the various replies being identified by a letter suffix.

A

Detailed control; moral effect on workmen; better control of maintenance and efficiency of a particular vehicle.

B

Comparisons are possible and available which are not obtainable by grouping or any other than the unit method.

D

When accounting is centralized at the garage headquarters and is at all times up to date, I believe costs should be kept for each individual vehicle. This gives the motor-vehicle supervisory people direct supervision over all money spent on any individual car. When

* Report of costs committee, Accounting Division, Transportation Section. H. D. Tisdale, chairman. J. S. Bordwell, E. D. Brown.

the organization is large and the accounting is handled by an auditor's office, the group system of accounting is probably all right.

E

We consider that operating costs should be by individual car and then by groups. We feel that the advantages derived by the individual record more than offset the cost of compiling it. We use this individual record for the replacement of the vehicle and for its operating performance.

F

I am of the opinion that different cost records should be kept covering each individual car in use by the utilities rather than by groups of similar makes or types of equipment. It would seem that if costs were only kept covering groups of cars, that in the event of it becoming desirable to obtain definite information covering any certain car it would be necessary to have data in detail to discover the information desired. In other words, if there is any need of keeping any record at all it certainly should be in sufficient detail to be of some value.

I

The individual method should be used as it assists in the elimination of equipment which for some reason or other has become costly to operate, and also enables those in charge of equipment to eliminate careless, and consequently, expensive drivers. A cost record by groups we believe serves as a valuable guide for the purchase of new equipment.

J

Results obtained from the use of unit costs derived for each individual unit of automotive equipment, have been of such a beneficial nature that we feel it would be a step backward to discontinue this practice even for group costs. Of recent date, the question was raised as to the cost of operating this system and we made an exhaustive study of the problem, not only by representatives of the transportation department, but by an outside specialist in cost accounting, whose report eliminated all possible prejudice. Considering the large amount of money spent annually in operating and maintaining equipment, it was found to be most desirable to maintain a unit cost system and in our efforts to develop an efficient system, the operation of which might possibly cost less than that on the basis of unit-per-car, we found the group system to be the only possible substitute. But, in adopting it, we could not save in clerical force, and other cost savings were practically negligible.

After considering the comparative benefits of the two plans, we elected to continue the unit-of-equipment cost-accounting system. We operate with supervisors of equipment in the field and, in all questions relating to equipment, the field reports of actual physical conditions are considered with the cost records. Cost records cannot be of the greatest benefit or wholly dependable without a periodic tie-in with actual physical conditions, just as we find that personal inspections of equipment do not tell the whole story or do not equal the benefits which can be derived from the use of unit cost records in conjunction with the physical inspections. These cost records are a medium of assistance to the equipment supervisors in determining the causes of trouble and high costs and thereby enabling us to take preventive measures against weakness in both manual and mechanical operations. Repair costs in individual cases have been high and through the individual car-cost records, the fact clearly stands out that certain parts are, or a unit of the equipment is, weak or not functioning properly. We have gone to the dealers with our cost records and proved to them the deficiencies in their equipment with a resultant exchange, modification or reconditioning of parts without cost to our company, thereby reducing our operating costs and furnishing a guide in purchasing new equipment so that our future requirements can be reasonably fulfilled.

Our records have disclosed excessive tire costs and the fault has been traced directly to the driver. Excessive charges for gasoline have been apparent and in furnishing our supervisors with the necessary data, their investigations have resulted in equipment adjustments. Also, education of the drivers and records of an unreasonable quantity of gasoline for certain cars have pointed out irregularities such as an individual, through collusion, using gasoline for his personal gain and sending through a charge to company equipment.

With knowledge of a constant check on costs of operating and maintaining equipment, the psychological effect on both the operating and maintenance men, is very marked and is a big factor in our effort to keep our costs down to a minimum.

Over a period of three years we made a reduction of 11.8 per cent in our operating rates per mile. Our cost records were a great factor in bringing about this satisfying result, being an appreciable amount, as the mileage figured into the millions.

Records of costs on individual cars have been of great assistance in deciding the question of replacement or turn-in equipment against an overhaul. The records show any peculiar weakness and indicate whether or not greater mileage should logically have been made by the equipment. By combining these historical facts with a physical inspection, our decisions have been more favorable to economy and efficiency than by deciding such questions through either one of these two media.

Now quoting from the letters favorable to the group plan of accounting or at least provisional, we have the following comments for review:

C

We favor deriving the costs of the operation of transportation equipment on a group basis rather than the individual cost on each car. Our opinion is that this enables us to keep a daily operating summary up-to-date and when the cost per hour for the cars in the various groups is given to the various departments, they then have this figure to use for the entire month, and it is not necessary to refer to any one car to get an accurate cost data on any job.

G-H

I believe that the question as to whether costs should be derived for each individual car, or by groups of similar make and type of equipment, is largely dependent upon the facilities which a transportation department has for being directly familiar with the physical condition and operating requirements of each piece of equipment under its jurisdiction. It is the practice of our organization to have all pieces of transportation equipment inspected at frequent intervals by a traveling inspector (mechanic) who not only goes over the car itself, but familiarizes himself with its use and includes any comments as to overloading, etc., with his report on the condition of the car.

Some other utilities, however, have direct supervision of transportation equipment scattered through a division, or district organization, with the transportation department only indirectly in touch with the physical condition and operating requirements of each unit.

It is my opinion that for the first condition, costs for individual cars are largely superfluous as they reflect, if properly kept, only those comments with which the transportation department, through the inspection system, is already familiar. In addition to this, they can show the cost of repairs only after such repairs have been completed, whereas efficient operation of equipment oftentimes required the turn-in of equipment rather than incurring the cost of a complete overhaul.

It has been our experience that the operating cost of equipment may appear to be lower than the average when, in reality, the car is in poor condition and in imminent need of overhauling. If the operating cost is depended upon, the car might not be turned in whereas the physical inspection would clearly indicate turn-in as the more desirable course.

Reverting to the comments by those favoring the single car plan, I will quote the following objections to the group plan:

A

Lose control of detailed costs; moral effect of workmen lessened; would effect proper tire records and gasoline economy; loss of comparative cost statistics of different makes of same type of cars.

B

Results are too general for use by transportation executives. In general, results are too indeterminate for practical comparisons.

D

The group system of accounting is the one in use by us. It does not give the operating men as good supervision as does the individual car system, but it does present a true over-all picture.

J

Modern cost accounting is not accomplished without the historical facts tying in closely with actual physical conditions. These two factors combined will result in economy and efficient operation. Group accounting appears to be too general to accomplish these desired results or at least to the extent that costs per car produce.

In summing up the points of particular interest, brought out in the foregoing comments, one of importance seems to stand out above the rest and that is: "What practical use shall we make of unit costs?" In satisfying ourselves on this point, we then will have our answer to the question at issue: "Should costs be derived for each individual car or by groups of similar makes and types of equipment?"

Modern scientific principals of cost accounting are not simply bookkeeping problems. To be sure, such records should be the basis for the distribution of costs and used for whatever accounting problems present themselves but their great

use today is in conjunction with operating, maintenance and construction problems.

Beneficial Results

It has been suggested that costs for individual cars are largely superfluous as they reflect only those comments with which the transportation department through the inspection system is already familiar and can show the cost of repairs only after such repairs have been completed. Another comment indicated that the cost system is used for accounting purposes only, such as establishing a basis for the distribution of charges. If these results, as indicated, are the only ones we desire to secure from a cost system, then a detailed cost system becomes a luxury and, from an economical standpoint, a simple bookkeeping record would suffice. If these are the only results by which we wish to benefit, we are missing a part of a system which can produce economy and efficiency in operation.

A detailed cost system properly kept and applied, will serve to furnish operating facts concurrently with the progress of our work. It not only establishes an historical record to be used as a basis for future activities, but properly applied to work in progress, will point out weak spots against which corrective measures can be used. From personal experience, I have observed that neither the cost record nor the actual physical inspection and inventory treated independently of each other produce the best results, but to synchronize these two elements which are necessary to efficient operation, greater results will be obtained.

Opinions on Basis of Costs

Of benefit to any company is the comparative feature of a cost system, for the basis of all units of measurement is comparison. This leads to the question of the most practical method of stating unit costs, also to the necessary degree of refinement of a total cost into its component parts. Bearing on this subject there are expressed opinions of various members, as follows:

A

We prefer hourly basis of cost for all equipment. We do, however, establish monthly rates for permanent assignments of vehicle equipment for collectors, meter readers, district cars where the distribution charge account remains the same throughout the month. The monthly rate is established only for a matter of convenience and less clerical work.

The hourly basis provides a more equitable distribution of costs against operating and construction accounts. In most all companies, labor is used as a basis for pro-rating all overhead clearing accounts, therefore it is reasonable to establish time as a charge basis for the use of vehicle equipment.

We prefer subdivisions of accounts as follows: gasoline, lubricants, tires and tire repairs, repair material, repair labor, painting labor and material, accidents labor and material, garage expense, total operating expense, rent and storage, insurance, licenses and taxes, general expense.

It helps to decide the proper selection of equipment for the purpose or district in which the cars are to be used. It enables us to make comparisons of the same make and style of cars in the same group used for similar purposes, such as meter readers, collectors, estimators, etc. The extreme difference in unit costs indicates something wrong with that particular car or the fault of the careless or negligent driver.

I like to feel sure that our costs are somewhat close to other companies' costs. If I find a great discrepancy of any class and make of cars I usually make a thorough investigation, therefore the comparisons are advantageous.

B

In case of automotive equipment only, per-mile is best basis of cost. Where a compressor is mounted on a truck, a per-mile basis should be used for the truck and a per-hour basis for the compressor unit.

All charges such as gasoline, oil, repairs, painting, accidents, tires, and depreciation should be made directly against the truck as they occur during the month. All other unsegregated charges should be lumped under "overhead" and pro-rated at the end of the month on an equitable basis to each car. Headings should be: gasoline quantity, gasoline cost, oil, chassis repairs, major and minor body repairs, painting, accidents, tires, depreciation, overhead, total miles, total cost, and cost per mile.

It renders possible a fair comparison of the performance of all units in the various work of the departments. Fitness of types or makes are readily ascertained.

Grouping of unit costs of a certain make of truck and comparing result with a similar grouping of another make, readily shows the most economic and furnishes an accurate control of cars not keeping up with the average cost mark set for their class and make.

Faults of car or driver or unsuitability of work on which car is employed are quickly evident.

A control of crew performance also is possible. Executives are enabled to check transportation expense, mileage, etc., as compared with work performed.

Estimates for future work can readily be made up from past records and a close approximation can be reached from past records.

Under the unit system, mileage is reduced to a minimum, as all mileage must be charged to a specific account and all such charges are auditable.

Amounts necessary for budgeting future expenditures for transportation can be ascertained for any given length of time.

D

We use the cost-per-mile as the operating unit indicating our efficiency of operating and we use the cost-per-hour as the unit with which to charge the usage of the equipment to the particular job it was working on. This latter practice, I believe to be correct in that the good luck or bad luck of any particular unit is no concern of the operating department using the unit. What such operating department is concerned with is how much is the vehicle going to cost them on their job. This cost can best be given them by establishing a per-hour clearing rate.

The subdivision of expense per motor vehicle as established by us, is as follows: chauffeurs' salaries and expenses, gasoline, oil, tire and tube replacements, vehicle license fees, miscellaneous, repair salaries and wages, repair material, accident salaries and wages, material, insurance, rents, garage service, operation of motor vehicle repair shops, general expense.

If the unit costs are not maintained, everybody is in a state of absolute darkness as to what the units are costing and it is impossible to know how to proceed to effect economies.

E

We feel that the logical unit for reporting charges for the vehicle to the work it is employed upon is the hourly rate. We use the mileage rate merely as a thermometer to watch any undue fluctuations.

It is our opinion in the subdivision of the various costs that gasoline, oil, tires, repairs, garage expense, overhead, depreciation, are sufficient headings for break-down of operating costs.

Results obtained by unit costs are so numerous and varied that they are hard to enumerate. Some of them are: condition of the motor, checking gas and oil mileage, by repair costs to determine whether the car should be replaced, garage expense to determine if too much expense is being incurred on the class of car used.

Benefits derived from comparing costs with other companies are hard to state, except that in cases where our operating costs are greater for a certain type of car than those of other associated companies in the same class of work, we immediately start to analyze operating conditions, class of equipment used, location, etc., to see if some remedy cannot be applied to make the costs more equal and to determine whether our forces are comparable with other companies.

F

While in some types of equipment it undoubtedly is true that the cost per hour might be of particular advantage in determining costs, in my opinion the best way to determine costs of all types of equipment is on the cost-per-mile basis. If costs per mile are accurately kept on this type of equipment it should be relatively easy to determine the cost per hour if it is necessary to determine at any time.

I would suggest that unit costs be computed covering gasoline, oil, tires, repairs, garage expense, and overhead depreciation. By obtaining unit costs I believe very favorable results occur to benefit our company in that we are able to determine not only that certain types or makes of cars are efficient to operate, but it is possible to determine accurately which unit might be efficient or inefficient, as the case might be.

Benefits to be obtained from comparing costs to those of other companies as kept at present are of some value, but unless they are all kept in approximately the same manner, they of course will be of no great value to any one.

I

Trucks which spend more than 50 per cent of their working time in hauling should have their cost calculated on a mileage basis, all others on an hourly basis.

We make a monthly report of all our automobile equipment which shows the following items: miles operated, total gallons gasoline, miles operated per gallon of gasoline, total cost per mile operated, and total cost for current month. This latter is subdivided as follows: lubricants; repairs, including repair parts; tires and tubes including repairs; accessories, not including repair parts; garage rent and service; license fees and insurance prorated per month; other expenses, if any, detailed.

Our monthly report is examined by department heads in charge of equipment and furnishes valuable data for the elimination of equipment which has become uneconomical to operate further. We also derive interesting operating data from the effects of using different types of gasoline, oils, tires.

We have been very much interested in receiving yearly reports of costs from other member companies and believe this practice very desirable. Undoubtedly, however, a further degree of uniformity in the arrangement of unit costs would make this comparison of reports much more valuable.

J

We derive all costs and charges for automotive equipment service on a mileage basis with the exception of winches, tractors and earth-boring machines, which costs are charged on a time basis. Our experience shows the mileage rate to be most satisfactory and equitable and that it does fulfill all requirements from both an accounting and operating standpoint. It appears to us that for comparative purposes, the mileage unit is the only logical plan.

Exceptions to the Foregoing Opinions

While the foregoing quotations favor to a great extent one general plan, the following exceptions have been offered:

C

We favor using the cost-per-hour basis, not the cost per mile. Our reasons are that a truck may be engaged on a job right in the business section of town for a period of ten days. During this time the actual travel of the truck will be but ten miles per day although the truck is on the job eight hours a day. Arriving at a cost considering fixed charges such as insurance, depreciation, interest, etc., which accrue on the truck irrespective of whether it is traveling or not, would make the cost per mile on that truck out of proportion to a truck which would travel 30 miles a day. Pro-rata share of the garage expense charged to this truck would remain fixed, irrespective of whether the truck traveled ten or thirty miles a day. Also, in arriving at the cost of the job on which this particular truck is working, it is much easier to use a cost-per-hour rather than attempt to compute the cost per mile of the truck while on the job.

In arriving at unit costs, subdivisions should be as follows: gasoline, oil, tires, repair parts, labor, garage expense, storeroom expense, depreciation, insurance, and interest on the investment. Storeroom expense is the net issues of stores against the group of cars and would be based on the value of the gasoline, oil, tires and repair parts charged against the group for the month.

Benefits of comparing with other companies are many. In this manner a check of our own operating is afforded and in cases where a company is fortunate in having a low cost of operation, ideas may be obtained to enable other companies to reduce their costs.

G-H

The logical unit for deriving and stating costs is, as I see it, largely a theoretical argument. Some combination of cost per hour and cost per mile undoubtedly comes nearer being accurate than either unit by itself. I, personally, believe it is largely a matter of personal preference and accounting expediency. If accounting and record-keeping requirements could be divorced from the problem, I would favor a mileage cost on all passenger and light service cars with a mileage cost on trucks used for long-distance hauling and an hourly cost for line trucks and other equipment in similar service.

As to the segregation of operating costs, a segregation covering gasoline and oil, materials and supplies, payroll, garage and overhead, and depreciation should be sufficient.

A careful consideration of the unit costs on individual pieces of equipment which are available for some of our cars, convinces me that, with the inspection system in operation, they are unnecessary and that any saving, due to their elimination, would be almost entirely a net gain. The unit costs by groups of similar make and type of equipment are useful in making the proper charges for the use of the equipment and in noting changes in the relative level of costs from month to month. Rapid changes which are taking place in the various models make a unit cost on a particular model largely useless in the selection of new equipment.

In the first few years that the transportation section operated, the comparison of unit costs constituted an effective means of bringing together the transportation heads of the various companies. This value, I felt, was more indirect than direct. Many differences in accounting procedure were brought to light, but here again the accounting standards of the various companies did not permit the change to an uniform accounting system. These differences, together with the different operating conditions, make a detailed comparison out of the question.

For these reasons, I believe that a comparison of costs by groups of similar make and type of equipment should be as useful as comparisons by individual units. In fact, I think it is fair to say that the comparisons which have been made in the past have been almost entirely as between groups and not by individual units.

Unit System Favored

The differences of opinion cited herein certainly are very marked, with the weight of evidence submitted favorable to a unit-cost system. However, in the use of such a system, we must consider first the practical results we wish to obtain, otherwise we may find ourselves in possession of an expensive luxury.

Results to be Obtained

We should not consider a unit cost system as an exclusive accounting expediency, but it must be used as a means toward economical and efficient operation and maintenance and it must be made to operate concurrently with the progress of our work, otherwise the element of luxury enters in. Preliminary plans for unit costs must provide for sufficient detail to show at all times the utmost economy in operation and maintenance, the greatest degree of utilization of equipment, and operating data such as gasoline consumption, tire costs, mileage, etc., for a check against all drivers. This data must be gathered at intervals of sufficient frequency to keep the inspectors advised of current operating facts which should be used in conjunction with physical examinations of equipment, and also to serve as a guide for corrective measures.

Actual expenditures which are reflected through the unit-cost records serve as a basis for all accounting purposes. The totals of the cost ledgers are transferable to the general ledgers and the cost details are convertible into any logical form for distribution purposes. It really is immaterial whether the jobs served are charged on a mileage or a time basis, just so an equitable distribution of costs is made. However, it would appear desirable to make charges on a basis similar to that used for the derivation of unit costs. This is a matter of economy with the best obtainable results.

Conclusion

In closing, I wish to touch upon the comparative features made possible by a unit-cost system. We may believe that we are operating efficiently and economically, but we cannot be positive of this until we measure our costs, and that is accomplished through comparisons. In citing the experiences of a representative number of member companies, costs are shown in sufficient detail and uniformity to produce certain groups of unit costs which are comparable and will furnish units of measurement which, if properly studied and applied, will be of benefit to the automotive equipment department of any utility company. It appears without question that comparisons should be made in groups of similar types and makes of equipment, as comparisons of individual cars would be too elaborate a study to be practical except in remote cases wherein certain operating conditions appeared questionable.

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*Transportation Cost Accounting Plan**

The Transportation Section desires to present in the following a uniform cost accounting plan for transportation vehicles which may be readily adapted to the needs of any company desiring to keep close executive control over automatic vehicles and their operation.

* Prepared for costs committee, Accounting Division, Transportation Section.

THE plan herein discussed grew out of the repeated discussion at section meetings of the relative merits of the individual cost accounting plan versus the group cost accounting plan. It is the desire of the Transportation Section to present a uniform cost accounting plan for transportation vehicles which may be adopted easily by the transportation department of any company desiring to keep close executive control over automotive vehicles and their operation.

In Fig. 1 is shown a diagrammatic presentation of motor vehicle cost captions used in this plan. It indicates how charges are handled, what operating charges are covered in the overhead accounts, and it suggests simple clearing accounts with instructions detailing how each clearing account is to be cleared. This set-up can be used for either a group of vehicles of the same kind, size and make, or for the individual vehicles.

Exhibits of motor vehicle operating ledger and report forms are shown in Fig. 2. These are described briefly.

Motor Vehicle Operating Ledger—

This is for either the individual unit or group of vehicles, but this cost ledger form is made up for a single vehicle and a sufficient number of lines are provided to keep a record of costs for a six-year period. Most companies provide additional columns for "cost-to-date" figures, but in order to conserve space and keep the size of the form to a minimum, it is suggested that the cost-to-date figure be carried forward in pencil in the same column along with charges for the month on the ledger sheet.

Motor Vehicle Monthly Operation Report—

The segregation of charge account is almost identical with the ledger sheet and is the monthly report of all the units by individual company number, or by class.

Motor Vehicle Comparative Cost Analysis—

This form can be used to make comparisons of operating costs with other Pacific Coast Electrical Association member companies.

It should be noted that the forms illustrated are almost identical, the ruling being the same and only minor changes in captions are necessary to make the form answer the purpose of either a ledger, monthly report, or a comparative statement, which not only standardizes captions, but effects economy in printing expense.

The foregoing set-up is almost identical with the records kept by several companies.

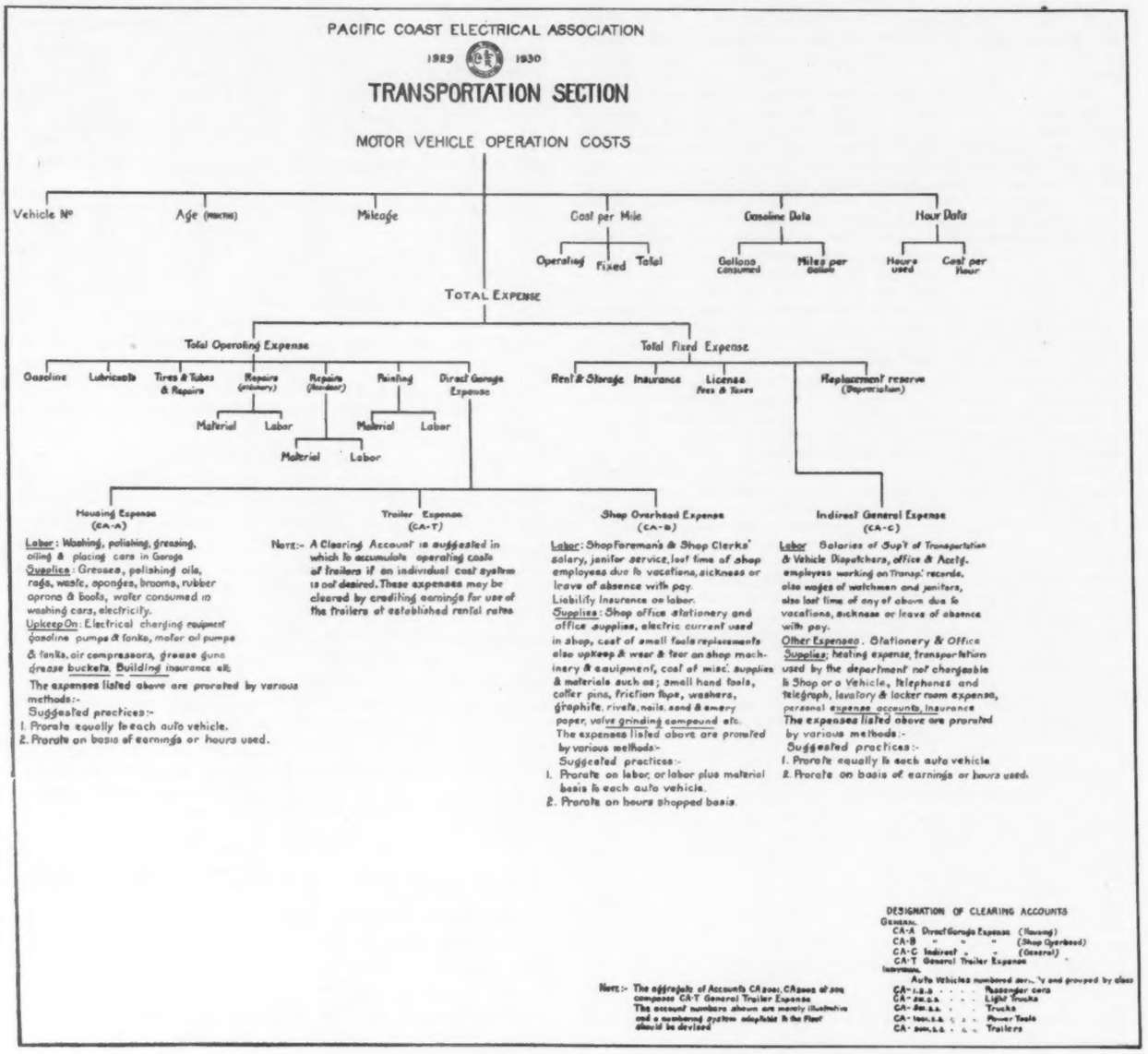

PACIFIC COAST ELECTRICAL ASSOCIATION
1929 1930
TRANSPORTATION SECTION
MOTOR VEHICLE OPERATION COSTS
Vehicle Nº
Age (months)
Mileage
Cost per Mile
Operating
Fixed
Total
Gasoline Data
Gallons consumed
Miles per gallon
Hour Data
Hours used
Cost per Hour
TOTAL EXPENSE
Total Operating Expense
Total Fixed Expense
Gasoline
Lubricants
Tires & Tubes & Repairs
Repairs (ordinary)
Repairs (Accident)
Painting
Direct Garage Expense
Material
Labor
Rent & Storage
Insurance
License fees & Taxes
Replacement reserve (Depreciation)
Housing Expense (CA-A)
Labor: Washing, polishing, greasing, oiling & placing cars in Garage
Supplies: Greases, polishing oils, rags, waste, sponges, brooms, rubber aprons & boots, water consumed in washing cars, electricity.
Upkeep On: Electrical charging equipment gasoline pumps & tanks, motor oil pumps & tanks, air compressors, grease guns grease buckets. Building insurance etc.
The expenses listed above are prorated by various methods:-
Suggested practices:-
1. Prorate equally to each auto vehicle.
2. Prorate on basis of earnings or hours used.
Trailer Expense (CA-T)
Note:- A Clearing Account is suggested in which to accumulate operating costs of trailers if an individual cost system is not desired. These expenses may be cleared by crediting earnings for use of the trailers at established rental rates
Shop Overhead Expense (CA-B)
Labor: Shop Foreman's & Shop Clerks' salary, janitor service, lost time of shop employees due to vacations, sickness or leave of absence with pay.
Liability Insurance on labor.
Supplies: Shop office stationery and office supplies, electric current used in shop, cost of small tools replacements also upkeep & wear & tear on shop machinery & equipment, cost of misc. supplies & materials such as; small hand tools, cotter pins, friction tape, washers, graphite, rivets, nails, sand & emery paper, valve grinding compound etc.
The expenses listed above are prorated by various methods:-
Suggested practices:-
1. Prorate on labor, or labor plus material basis to each auto vehicle.
2. Prorate on hours shopped basis.
Indirect General Expense (CA-C)
Labor Salaries of Sup't of Transportation & Vehicle Dispatchers, office & Acctg. employees working on Transp.' records, also wages of watchmen and janitors, also lost time of any of above due to vacations, sickness or leave of absence with pay.
Other Expenses. Stationery & Office Supplies; heating expense, transportation used by the department not chargeable to Shop or a Vehicle, Telephones and Telegraph, lavatory & locker room expense, personal expense accounts, Insurance
The expenses listed above are prorated by various methods:-
Suggested practices:-
1. Prorate equally to each auto vehicle
2. Prorate on basis of earnings or hours used.
Note:- The aggregate of Accounts CA 2000, CA 3000 & 4000 composes 'CA-T General Trailer Expense.
The account numbers shown are merely illustrative and a numbering system adaptable to the Plant should be devised
DESIGNATION OF CLEARING ACCOUNTS
General.
CA-A Direct Garage Expense (Housing)
CA-B " " " (Shop Overhead)
CA-C Indirect " " (General)
CA-T General Trailer Expense
Individual.
Auto Vehicles numbered 001 to 1999 and grouped by class
CA-1 to 1999 . . . . Passenger cars
CA-2000 to 2999 . . . . Light Trucks
CA-3000 to 3999 . . . . Trucks
CA-4000 to 4999 . . . . Power Tools
CA-5000 to 5999 . . . . Trailers

Fig. 1. Diagrammatic presentation of motor vehicle cost captions.

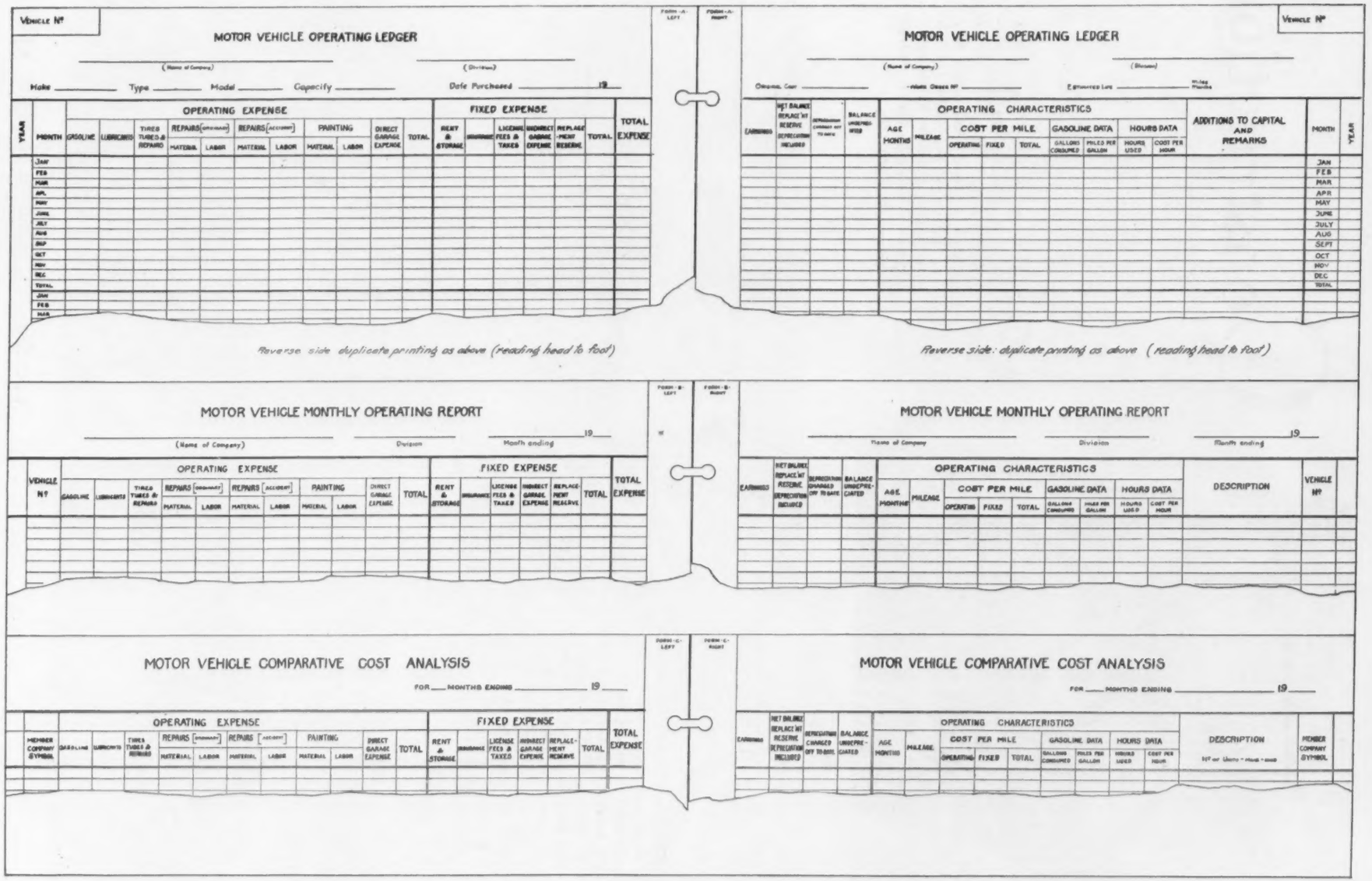
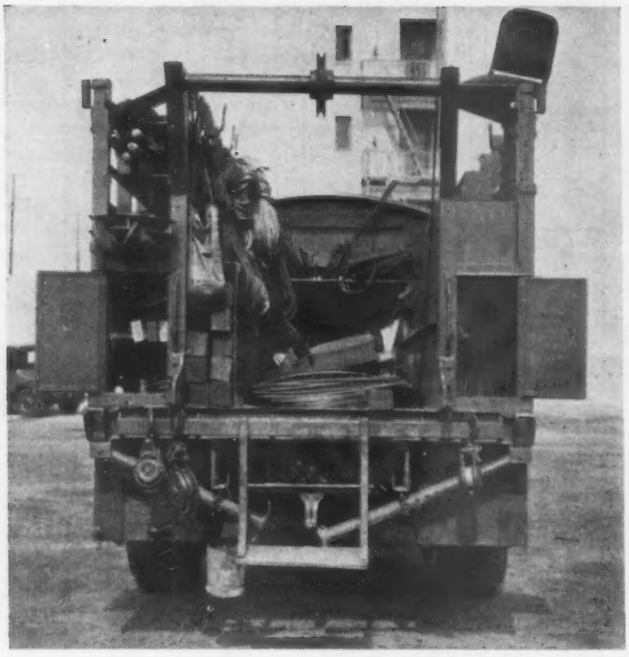
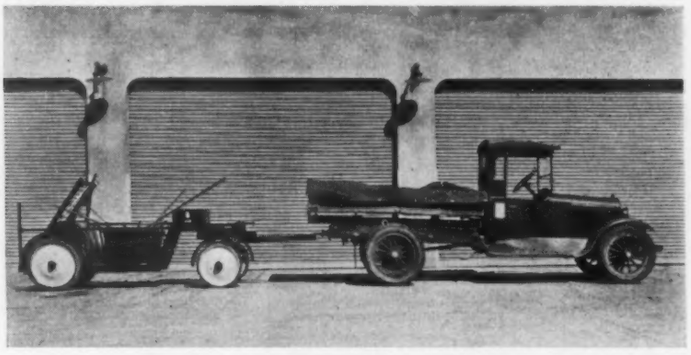


Fig. 2. Exhibits of motor vehicle operating ledger and report forms.



Construction

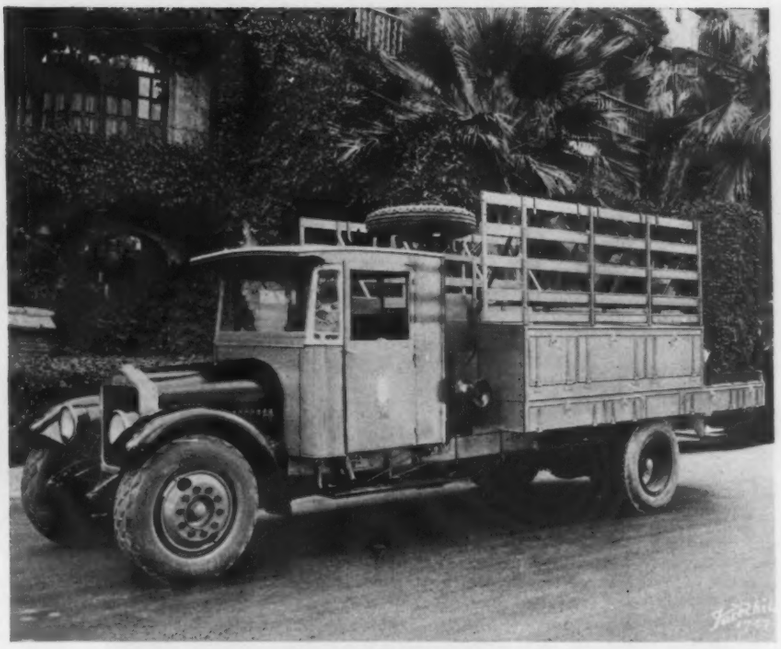
AT THE left is shown a line construction truck, rear view, revealing the space provided for material stowage. Another view of this same truck, with its pole-derrick raised, may be found at the bottom of this page (right). Below is a light truck and trailer combination designed especially to facilitate the repair of street pavements



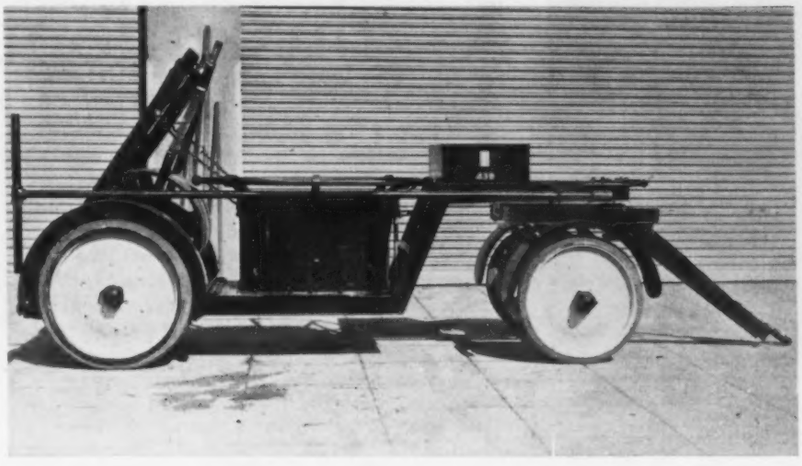
TWO other views of line construction trucks are shown below. At the left the truck is covered with its canopy for weather protection and is hauling a trailer for surplus materials. At the right (below) is a truck with its pole-derrick raised and ready for use in setting or lifting poles

"Vocational Application of Motor Vehicles"

Equipment

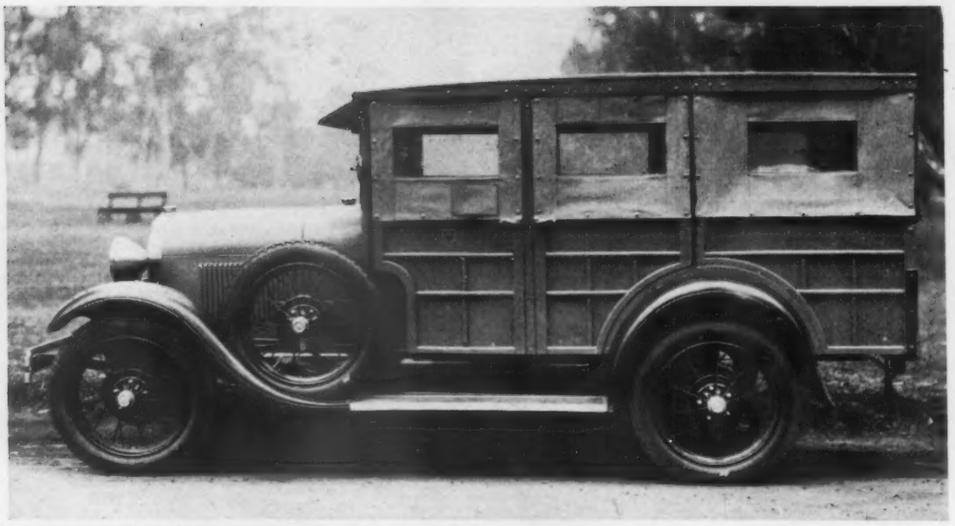


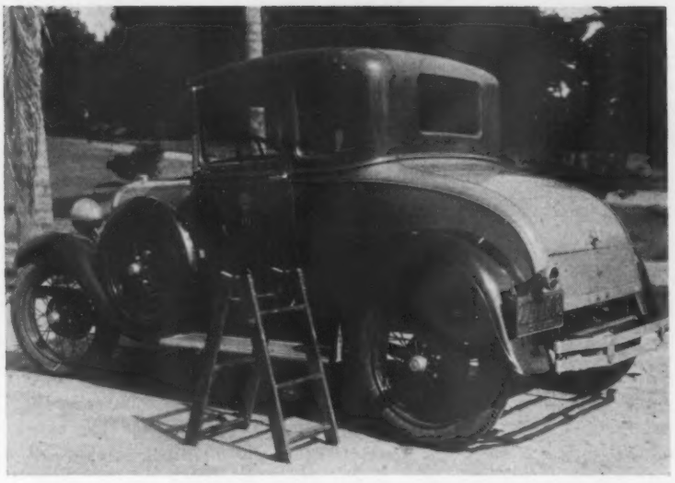
SPECIALLY fitted line truck which can haul poles is shown at the right. Below is shown a close-up view of the street paving repair trailer with its complement of tools



FOR heavy-duty service the six-wheel equipment shown immediately below is a necessary piece of transportation equipment. Note the bins and other conveniently arranged storage space for construction incidentals. Below at left there is shown another view of the truck and trailer combination pictured on the facing page

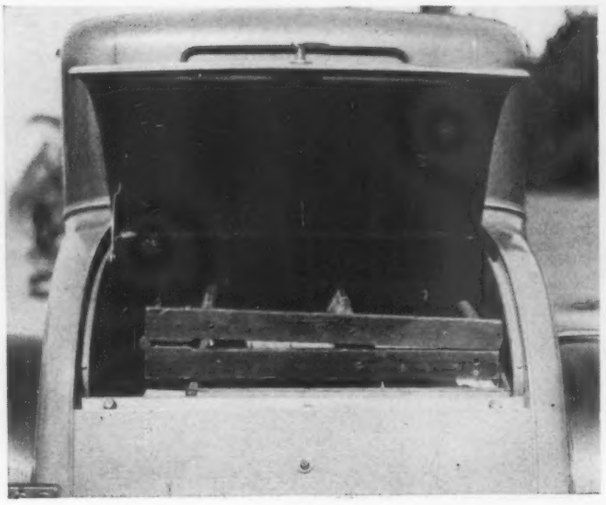
Transportation Section, P. C. E. A.

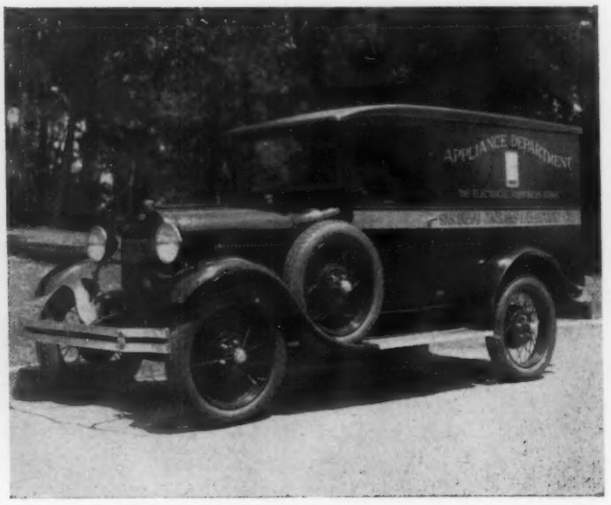




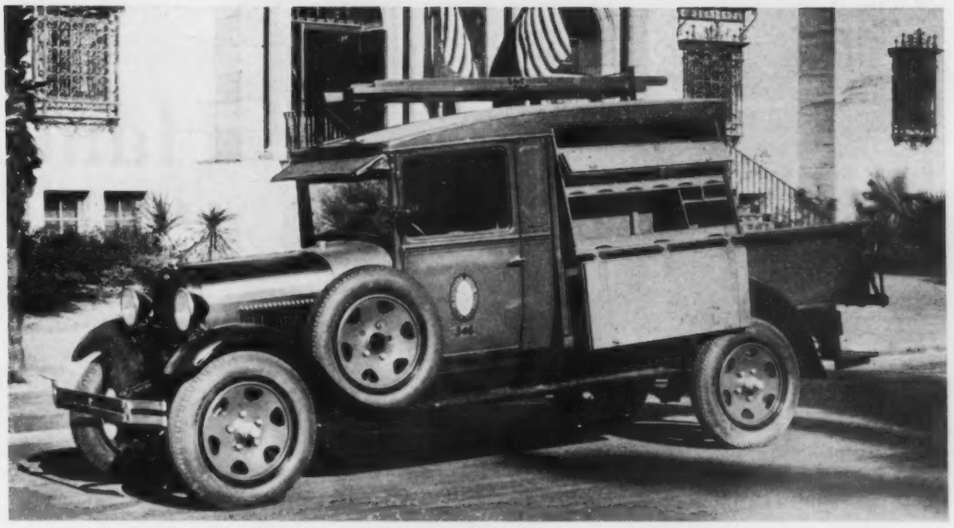
Convenient

LIGHT equipment for light and special duty is convenient and economical. A surveyor's car is shown at the top of the page. At the left there are two views of a light coupe for meter readers and "turn-on and turn-off" men. Note the collapsible ladder which fits into the rear compartment. Immediately below may be seen a panel-body appliance delivery truck

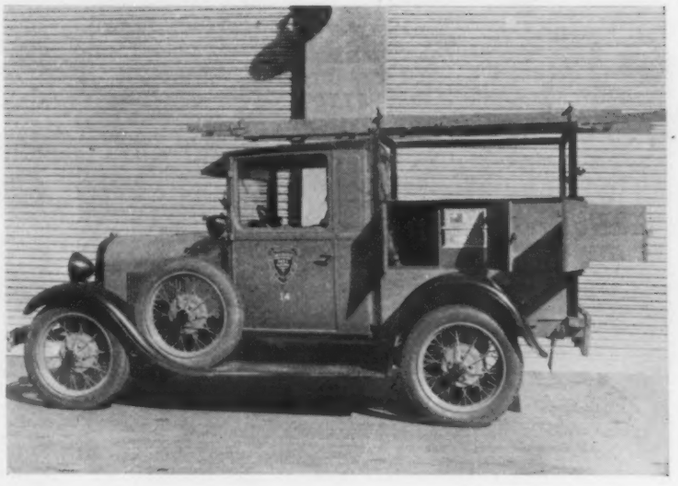




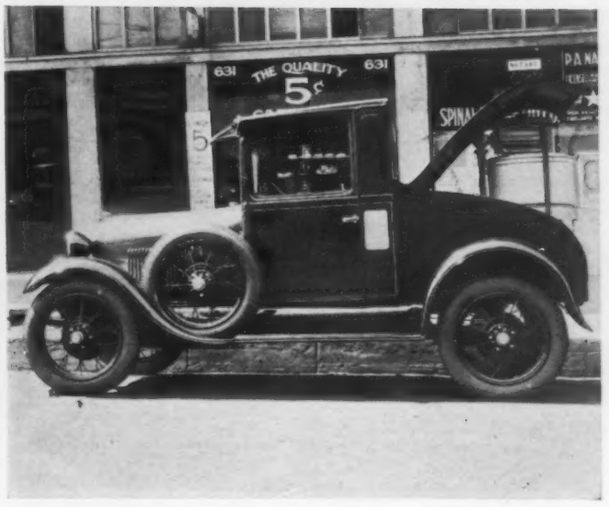
"Vocational Application of Motor Vehicles"



Service Cars

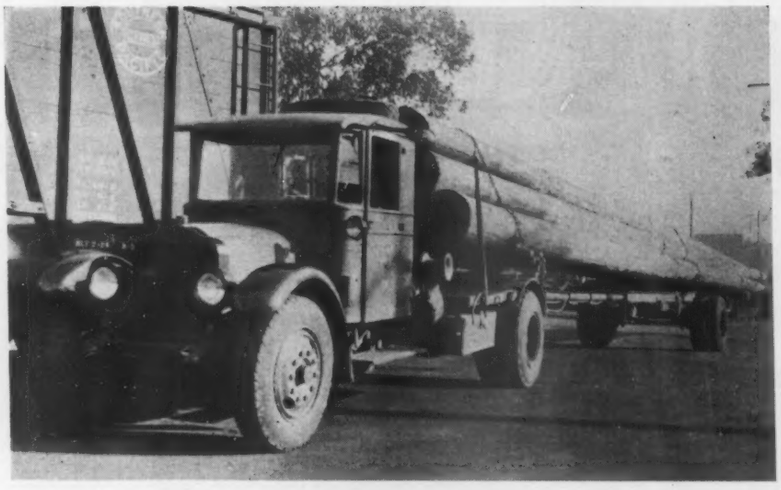


A SERVICE and meter installation truck with a body specially designed to accommodate tools, materials, and collapsible ladder is shown at the top of this page. At the right is a trouble-shooter's car, also conveniently equipped. Below (left) is a rear view of this same car. At the right (below) is shown a light pick-up car which serves well for merchandise deliveries by merchandise salesmen

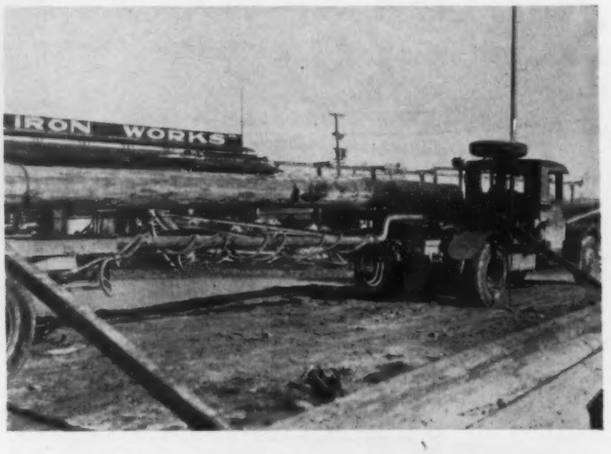


Transportation Section, P. C. E. A.

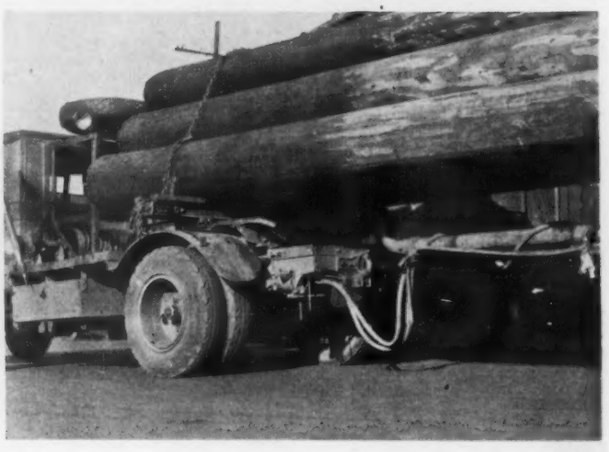
Handling Poles



ABOVE *is shown a 2½-ton truck with a pole trailer, both with pneumatic tires, for field deliveries of poles. A driver and one helper can unload with the aid of skids and winch line (left). Immediately below is another view showing hose connections for air brakes on trailer*

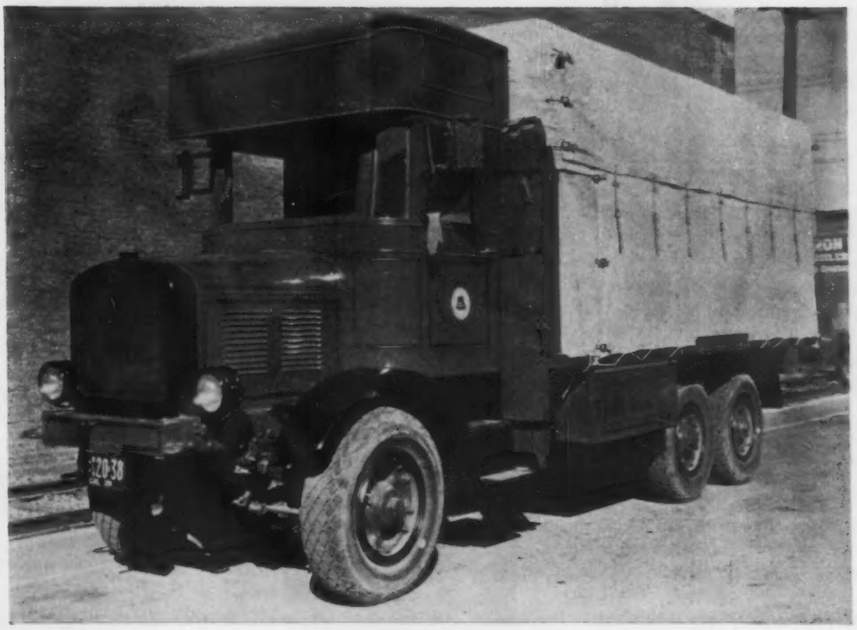


TRACTOR *and semi-trailer combination hauling 25-ft. poles may be seen below (left) while at the right below is another view of the equipment shown above, showing trailer tongue connection which permits truck to turn 90 deg. with respect to pole load. Vacuum booster brakes on truck operate vacuum brakes on trailer through hose*

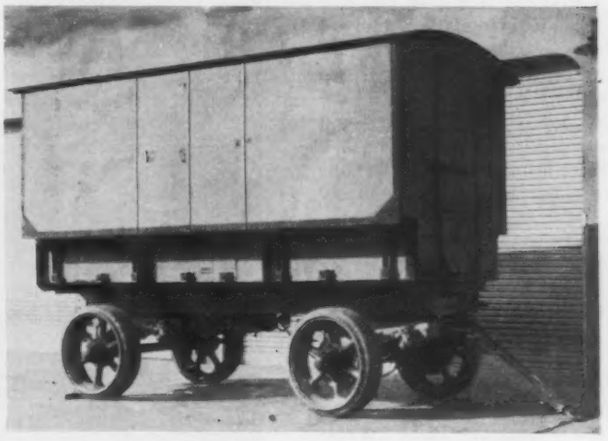


"Vocational Application of Motor Vehicles"

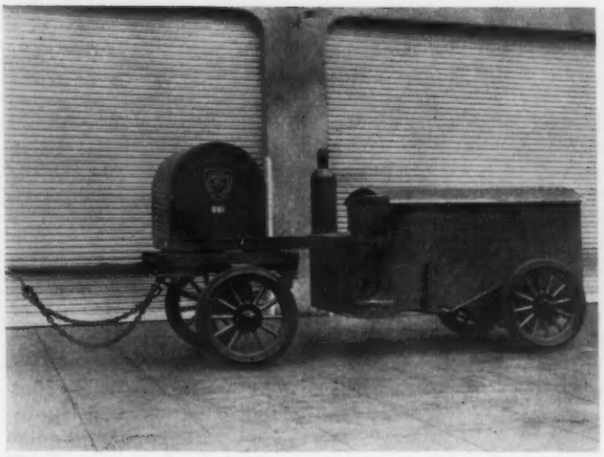
Special Equipment

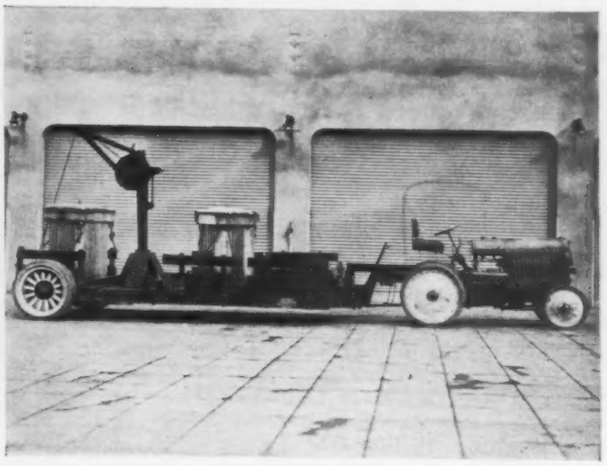


A *SIX-WHEEL general utility freighter may be seen above. Immediately below is shown a portable electric and acetylene welding outfit with cable reels conveniently mounted. At the bottom of this column is shown the same equipment covered and ready for the road*



Above is a heavy-duty trailer for construction tools and materials. Below is a general tractor and semi-trailer combination for shuttle work





Transportation Section, P.C.E.A.

Progress in the Northwest

By M. L. HIBBARD
President, Northwest Electric Light and Power Association

ANOTHER milestone in the affairs of the Northwest Electric Light and Power Association is approaching, and the time for the annual recapitulation has arrived. Once again is the president able to report satisfactory progress. During the year just past all companies enjoyed increases in kw.-hr. sales and gross earnings, and all have completed various betterments to their physical properties, for improvement of service on their systems.

The second successive year of pronounced and general drought conditions was successfully weathered by all the member companies without the necessity of curtailing service or employing any extraordinary measures. Additional steam units at some points in the territory assisted materially in keeping the situation from becoming critical, and have increased the ratio of steam to hydro generating capacity in the territory, giving assurance that a continuance of drought conditions will be adequately met.

M. L. Hibbard

A number of excellent records in merchandise sales were achieved in 1929, and the effect of such intensive effort is found reflected in the increasing number of kw.-hr. sold per domestic customer by all the companies in the territory. Furthermore, many of the companies are entering more and more ardently into the business of serving the farms in their territories through the establishment of specially trained rural electrification departments. Statistics published by the rural electric service committee show many new farms added to the lines of the central stations in the Northwest and a more wide-spread use of the service by farms already served.

The work of the association has gone forward with continued vigor as the committee reports published in the following pages will indicate. Reference to all these reports herein is scarcely necessary, but I would like to invite particular attention to some of the work of each section, without, by so doing, seeming to imply that all of the work has not been important.

Following the plan instituted two years ago, the Accounting Section has continued its studies of taxation and wage scales in addition to its more routine work of keeping pace with developments in the field of accounting. In that field the section has made some important studies of the application of machines to various accounting operations. The section's annual meeting in March extended over two days instead of one.

An unusually productive meeting of the Commercial Section was held in the middle of February when ten committees under the three bureaus presented for discussion the results of their deliberations on the different kinds of load-building operations. Of particular interest was the program of the rural electric service committee which brought out many important phases of its problems. All the committee reports published in the following pages contain information of interest to the men responsible for the commercial development of our companies.

One of the principal accomplishments of the Engineering Section has been the commencement of research on radio interference caused by high-tension insulators. An experimental line for actual service tests of various insulators has been constructed at the Oregon State College, Corvallis, and laboratory tests are under way by the electrical engineering staff of that institution which is cooperating in the work. This is a national project which has been assigned to the Engineering Section of the Northwest Division for completion.

The annual meeting of the Engineering Section in March was the best attended of any yet held. Many subjects of interest and importance to Northwest companies were presented and discussed, and, as has been customary in recent years, the proceedings of the meeting will be produced in a separate booklet.

Public speaking again has been the central feature of the activities of the Public Relations Section. With the national contest as an incentive this year, the interest among member company organizations has been greatly stimulated. The winner of the Portland finals, May 17, will represent the Northwest at the national contest in San Francisco.

Because the national convention is to be held this year in San Francisco, it was decided to hold no general convention of the Northwest association, but rather to permit the Northwest companies to concentrate their efforts on the national convention. Besides sending ample delegations to San Francisco, several of the Northwest companies are preparing to entertain Eastern delegates whose routes to or from San Francisco carry them through the Northwest states. It is hoped that our Eastern colleagues will find much to interest them on their visit to the Pacific Coast.

Accounting Section Reports[1]

Introductory Statement

By M. J. WILKINSON, Chairman

MOST of the work of the committees of the Accounting Section was brought to a climax at the Section conference held in Portland, March 17-18, 1930. This meeting was fully covered in summary form in the April 1 issue of ELECTRICAL WEST.

In the following pages are reproduced most of the committee reports and papers presented at that meeting.

[1] Executive Committee: M. J. Wilkinson, chairman; R. H. Jones, vice-chairman; O. W. Bennett, F. W. Brownell, W. L. Fitzpatrick, A. E. Janssen, A. J. Johnstone, G. F. MacKenzie, V. T. Montgomery, B. H. Parkinson, N. B. Whittier.

CLASSIFICATION OF ACCOUNTS COMMITTEE

*Classification of Accounts**

THE work assigned to this committee for the current year was that of taking such steps as were necessary to obtain adoption of the standard form of annual report recommended by the National Association of Railroad and Utilities Commissioners.

After canvassing the situation, it was found that the State of Idaho already was using the desired form of report and it was unnecessary to do any work in that state.

In the state of Montana it was found that the commission of that state had not yet adopted the standard classification, and the committee representative in Montana, therefore, confined his efforts to that of doing such work as he could toward obtaining the adoption of the standard classification. His report indicates that the members of the Montana commission are well disposed toward the standard classification, but heretofore have been reluctant to prescribe it officially out of consideration for the many small utilities throughout the state on whom the change might work a hardship. He also advised that they are hopeful of accomplishing the adoption of the recommended classification during 1930.

The Utah representative of the committee advised that he had made a comparison of the standard form of report with the form which now is being used by the Utah utilities and found the two forms identical with the exception of the printing and one or two minor differences as to the general set-up of the various forms. On account of the similarity between the standard form and the form now used in Utah, it is hoped that we will be able to get the commission to adopt the standard form without any difficulty, and this thought has been suggested to the Utah representative of the committee.

In the state of Oregon it has been impossible to make any headway due to the fact that the Oregon commission's very limited staff of engineers and accountants has been extremely busy during the past year in connection with the Portland power rate and street railway fare cases. The standard form of report has been placed in the hands of the commission's engineers and accountants and it is hoped that the Oregon representative of the committee will have an opportunity to discuss the matter with the Oregon commission within a reasonably short time.

In the state of Washington the committee representative has submitted to the Department of Public Works the standard form of report, together with a statement showing the principal differences between the present form of report and the standard form. The department's accountants have been very busy and have not as yet been able to go into this matter, but they have assured the committee representative that this will be done as soon as one of their accountants can be made available.

It is, of course, realized that a job of this sort will of necessity take considerable time. The committee, during the current year, has taken such preliminary steps as seemed advisable in each of the states and will continue to follow the matter as closely as possible. It is quite unlikely that anything further can be done for the current association year and, no doubt it will be necessary for the committee for the next year to take up this particular job where it is left by the present committee.

* Report of the classification of accounts committee. O. W. Bennett, Puget Sound Power & Light Company, chairman.
Idaho Power Company: G. O. Stoehr.
Montana Power Company: J. R. Thomas.
Pacific Northwest Public Service Company: E. W. Moreland.
Pacific Power & Light Company: W. T. Neill.
Utah Power & Light Company: L. A. Seare.

CUSTOMERS' RECORDS COMMITTEE

*Customers' Records**

THE report of the customers' records committee consists of the following papers presented by committee members at the Accounting Section meeting, March, 1930:

Billing 30-Day Merchandise and Installment Charges on Service Bills, by F. L. Nagel.

Accounting and Collection Plan for Closed Accounts, by H. B. Booth.

Consumers' Accounting Methods, by Gus Anderson.

Hollerith Machine Consumers' Accounting, by C. F. Kerchhaine.

* Report of the customers' records committee. N. B. Whittier, Pacific Northwest Public Service Company, chairman. F. L. Nagel, Northwestern Electric Company, vice-chairman.
Pacific Northwest Public Service Company: H. B. Booth.
Puget Sound Power & Light Company: C. F. Kirchhaine.
Utah Power & Light Company: Gus Anderson.

*Billing Thirty-Day Merchandise and Installment Charges on Service Bills**

By F. L. Nagel

MOST public utility companies operating in the Northwest are engaged in selling merchandise and in doing jobbing work as an adjunct to what might be termed strictly public utility business. In this respect, their problems are not unlike those of the general merchant. Books of account must be kept, bills rendered, and collections made.

The utility company does enjoy, however, an advantage not available to its merchant competitor, which, in many companies, is overlooked. The utility company, due to the nature of its business and the universal demand for its service as a household necessity, is in periodic contact with its service customers. Meter readings usually are taken monthly and bills for service delivered equally as often. In most companies this monthly contact is taken advantage of, by the sales department, by the insertion in the envelope, or attachment to the monthly service bill, of stuffers advertising the sale of certain appliances. This is a ready means of placing advertising in the customer's hands at the minimum cost. The customer's department in many companies, notwithstanding that they issue service bills, seem to ignore this advantage completely.

Need for Economy

Since most merchandise is sold on "time" or the installment payment plan under which payments may be spread out over from six to twenty-four, and in some instances more monthly installments, a statement for each of which must be presented to the debtor, and since competition is keen, and selling expenses and the cost of labor high, one may readily appreciate the necessity for the strictest economy in billing and collection procedure.

Presenting monthly statements to service customers entails certain cost, which is correspondingly increased by the number of times bills must be delivered. If statements are delivered for two or three months in advance, the cost of carrying such customers naturally would be considerably decreased, yet in many cases, the opportunity for delivering to the customer all of his monthly statements at one time is overlooked. It is safe to estimate that at least 85 per cent of the customers purchasing merchandise from a utility also are receiving from the same company electric or other utility service for which they receive monthly statements, and in many companies these same customers receive separate statements each month for their merchandise installments. This is wasteful.

The same customer could go to a department store and make purchases in any number of different departments, and at the end of the month receive one statement covering all of his account. That this also can be done by the utility company is indisputable. Details in each instance must be worked out by department managers to fit existing systems of accounting. The following outline is believed, however, to be readily adapted to any system, with some eliminations or additions.

Suggested Procedure

When charges are entered in the merchandise ledger, the address on the order from which they are taken may be checked against the consumer's ledger for the same address and, when it is found that the merchandise customer is also a service customer, a symbol or note may be made on the ledger page thus calling the attention of anyone scrutinizing the page to such fact. Thereafter, when each monthly service bill is rendered from such ledger page, the symbol or note may be seen, and the bill checked against the merchandise ledger, and the merchandise or any other charges readily entered on the same bill, which then can be totaled and sent to the customer. Thus the customer may pay his total monthly obligations to the company in one remittance by mail, at the company's office, or at an authorized pay station.

Advantages Other Than Economy

The saving effected is obvious, nor is this the only benefit derived. At least one unfavorable customer contact has been eliminated. It is believed that all will agree that the receiving of bills seldom produces favorable reaction. Human nature makes us rebel against the request for money. Consequently, the fewer bills the customer receives, the fewer are the chances for irritation. The amount of the bill often is not as irritating to the customer, as is the number of bills he receives.

Let us briefly consider the reaction of the average housewife. We will assume that she has received a statement for the installment due on the range purchased from the company. She has paid this on the tenth of the month. A few days later she may receive her monthly service bill, providing the company is one that has a continuous meter reading system, which is necessary in the larger cities. She does not think of them as two transactions. To her it is annoying. She has purchased merchandise from the electric company and she gets service from it, to her it is one account, but two separate statements are sent to her. Why cannot both be included on one bill? Such expressions often are heard from customers of companies that do not bill merchandise with their service accounts.

There also is a collection advantage in carrying merchandise charges on the service bill that should not be overlooked. To the average customer, it is the bill from a utility company, and is considered an account for a household necessity, the failure to pay which, may cause inconvenience in the discontinuance of service. Seldom is the merchandise charge, when it appears on the service bill, considered separately, and when the bill is paid, the remittance usually covers the total amount. Then again, should the customer call at the company's office and express a desire to pay only the service charge, a revised bill may be necessary, thus affording an excellent opportunity for the collection man to interview the customer, and prevent the account from going stale.

* Report prepared for the customers' records committee.

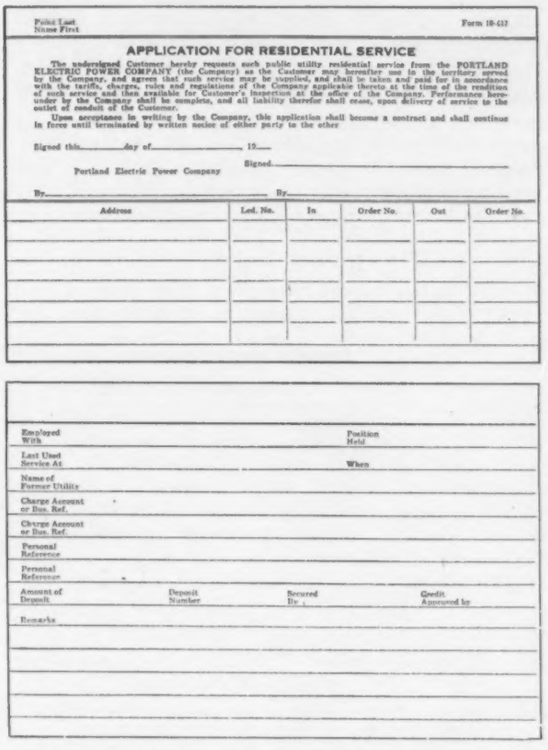
*An Accounting and Collection Plan for Closed Accounts**

By H. B. Booth

THE closed or final account occupies a very important place in the collection department, for it is through this source that the company's bad-debt losses

* Report prepared for the customers' records committee.

ultimately accrue. Time will not permit covering this subject in detail, but a few of the important steps necessary for the efficient collection of the account will be pointed out. The subject might be classified as follows: The opening of the account, the closing of the account, and the collection follow-up.



APPLICATION FOR RESIDENTIAL SERVICE

The undersigned Customer hereby requests such public utility residential service from the PORTLAND ELECTRIC POWER COMPANY (the Company) as the Customer may hereafter use in the territory served by the Company, and agrees that such service may be supplied, and shall be taken and paid for in accordance with the tariffs, charges, rules and regulations of the Company applicable thereto at the time of the rendition of such service and then available for Customer's inspection at the office of the Company. Performance hereunder by the Company shall be complete, and all liability therefor shall cease, upon delivery of service to the outlet of conduit of the Customer.

Upon acceptance in writing by the Company, this application shall become a contract and shall continue in force until terminated by written notice of either party to the other

Signed this_____day of_____, 19____

Portland Electric Power Company

Signed_____

By_____ By_____

Address	Led. No.	In	Order No.	Out	Order No.

Employed With — Position Held

Last Used Service At — When

Name of Former Utility

Charge Account or Bus. Ref.

Charge Account or Bus. Ref.

Personal Reference

Personal Reference

Amount of Deposit — Deposit Number — Secured By — Credit Approved by

Remarks

Fig. 1. Face and reverse of "application for service" card. Space is provided for rather complete information which may simplify matters later on.

Opening the Account

At the time the application is secured, sufficient information should be obtained to enable the collection department to locate the consumer who vacates the premises without giving notice and leaves behind an unpaid balance. Assuming that most people are honest and really intend to pay their bills, little difficulty is experienced with the account if the company has the forwarding address of the debtor. It is quite essential, therefore that information such as the following be secured at the time the application is signed:

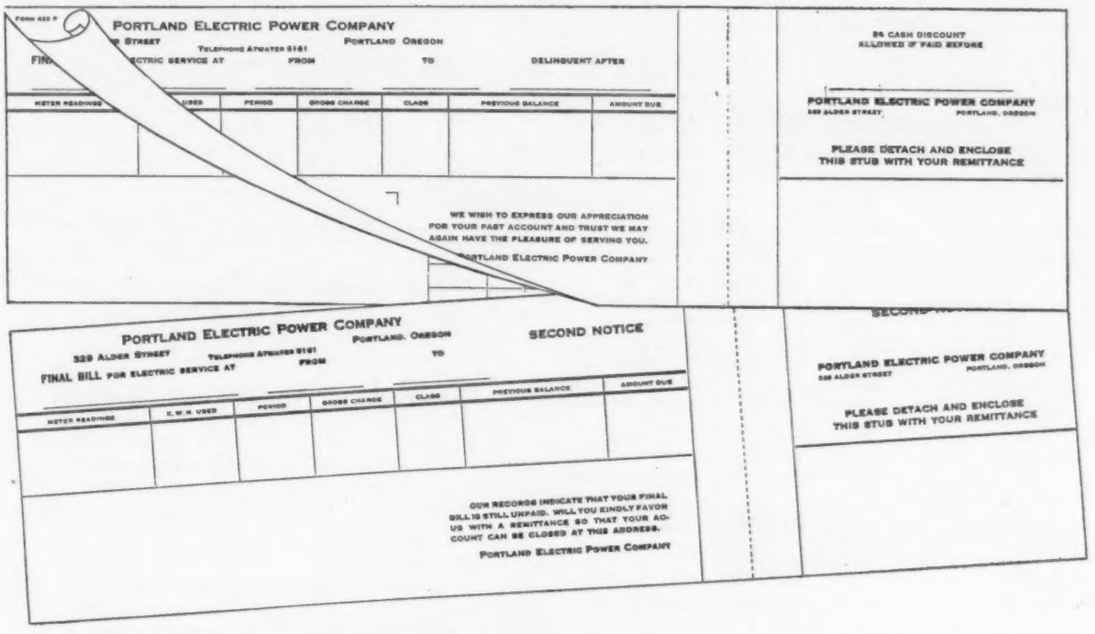
1. Present occupation, specific vocation and where employed at time of application.
2. Name of former utility.
3. Charge account or business reference.
4. Personal reference and relative outside of immediate family.

This information is not always obtainable but should be secured when possible.

Closing the Account

Upon the closing of the account, extreme care should be exercised to secure the customer's forwarding address and other data which are necessary for the collection of the account. It is advisable to centralize this responsibility in order properly to instruct those who make the contact in securing as much information as possible to enable the proper follow-up of the account. Experience also has shown that the promptness with which the account is followed for collection has a definite bearing on the results. This should not exceed a period of fifteen days.

The Pacific Northwest Public Service Company has had in operation for a year an accounting plan for final bills which has proved most efficient and is so arranged that it is possible to concentrate collection activities systematically and to ascertain at any time just how much the outstanding balances are on all closed accounts. Briefly, the procedure is as follows:



PORTLAND ELECTRIC POWER COMPANY

PORTLAND OREGON

METER READINGS | K.W.H. USED | PERIOD | GROSS CHARGE | CLASS | PREVIOUS BALANCE | AMOUNT DUE

WE WISH TO EXPRESS OUR APPRECIATION FOR YOUR PAST ACCOUNT AND TRUST WE MAY AGAIN HAVE THE PLEASURE OF SERVING YOU.

PORTLAND ELECTRIC POWER COMPANY

2% CASH DISCOUNT ALLOWED IF PAID BEFORE

PORTLAND ELECTRIC POWER COMPANY

PLEASE DETACH AND ENCLOSE THIS STUB WITH YOUR REMITTANCE

PORTLAND ELECTRIC POWER COMPANY

SECOND NOTICE

FINAL BILL FOR ELECTRIC SERVICE AT

METER READINGS | K.W.H. USED | PERIOD | GROSS CHARGE | CLASS | PREVIOUS BALANCE | AMOUNT DUE

OUR RECORDS INDICATE THAT YOUR FINAL BILL IS STILL UNPAID. WILL YOU KINDLY FAVOR US WITH A REMITTANCE SO THAT YOUR ACCOUNT CAN BE CLOSED AT THIS ADDRESS.

PORTLAND ELECTRIC POWER COMPANY

PORTLAND ELECTRIC POWER COMPANY

PLEASE DETACH AND ENCLOSE THIS STUB WITH YOUR REMITTANCE

Fig. 2. Final bill, made up in special triplicate form. The duplicate is held for ten days for collection follow-up if required. Triplicate is arranged to provide for the ledger record.

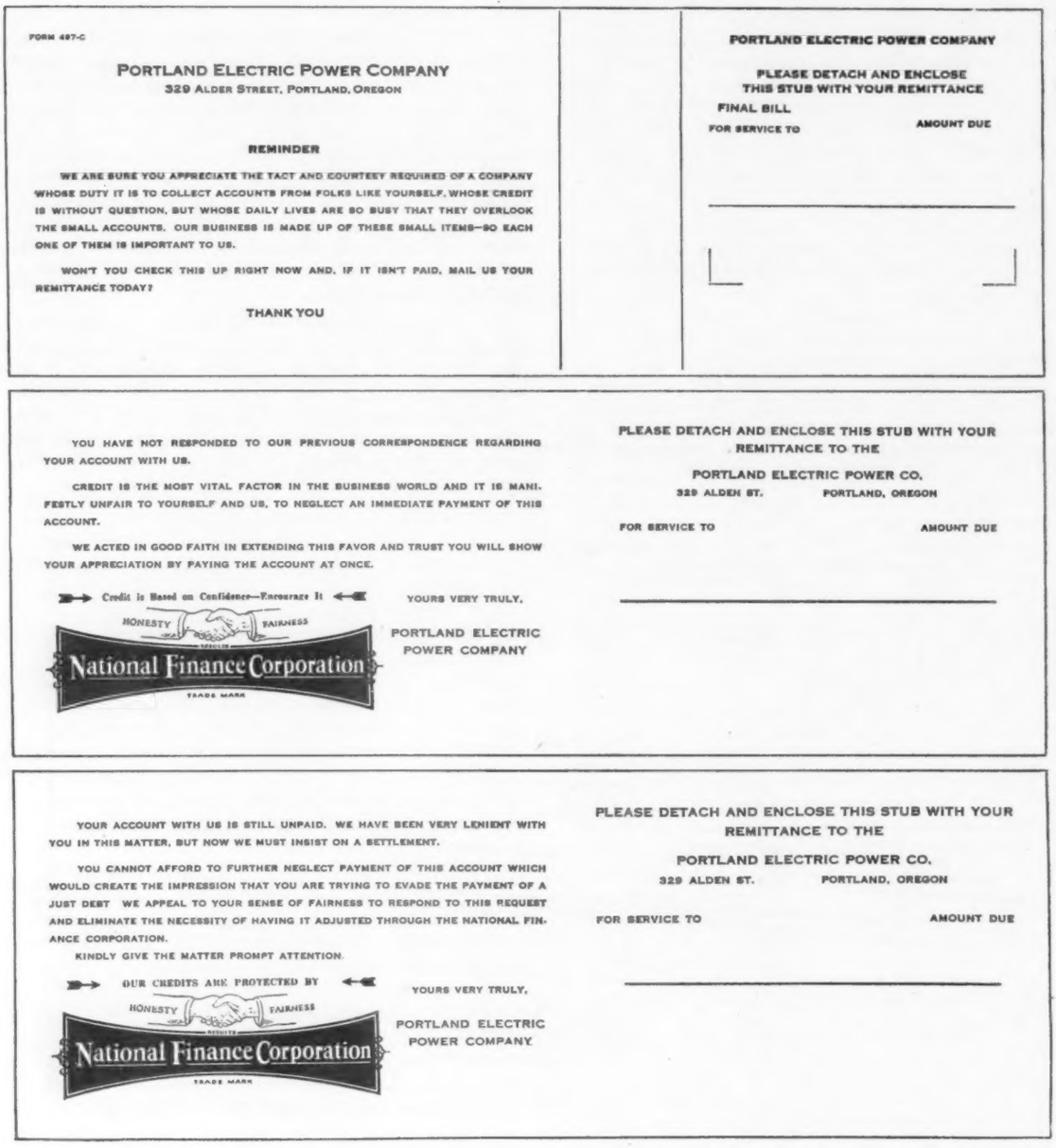
Collection Follow-Up

At the time of closing the account the final bill is made up in triplicate, the original going to the consumer, the duplicate being held for ten days for collection follow-up if not paid, and the third copy so arranged as to provide for the ledger a record which shows the amount of the final bill and also the previous balance, if any. The previous balance is taken care of through a transfer balance stub which is attached to the ledger record, the stub being used as a posting medium to close the current account. These triplicate bills are filed alphabetically as a permanent record and all collection procedure thereafter is followed from these records. Cash is posted daily. Paid accounts are removed and filed permanently for future record at the end of each week when trial balance is taken.

Bad debts are written off and deposits are applied at the end of each month to the closed bill file. A notation then is made on the customer's credit card, indicating that the account has been charged to bad debts and the final bill record is filed alphabetically for reference in case the customer applies for future service.

Collection Letters

A collection letter is an ambassador on a difficult and delicate mission and if poorly written is a wrecker of good will. On the contrary, a well written collection letter is a promoter of good will and therefore it should be studied and analyzed so that it will not fail in its proper mission. In theory there are, and in ideal practice there should be, as many different kinds of collection letters as there are accounts, each letter differing from the others because of the size and character of



FORM 497-C

PORTLAND ELECTRIC POWER COMPANY
329 ALDER STREET, PORTLAND, OREGON

REMINDER

WE ARE SURE YOU APPRECIATE THE TACT AND COURTESY REQUIRED OF A COMPANY WHOSE DUTY IT IS TO COLLECT ACCOUNTS FROM FOLKS LIKE YOURSELF, WHOSE CREDIT IS WITHOUT QUESTION, BUT WHOSE DAILY LIVES ARE SO BUSY THAT THEY OVERLOOK THE SMALL ACCOUNTS. OUR BUSINESS IS MADE UP OF THESE SMALL ITEMS—SO EACH ONE OF THEM IS IMPORTANT TO US.

WON'T YOU CHECK THIS UP RIGHT NOW AND, IF IT ISN'T PAID, MAIL US YOUR REMITTANCE TODAY?

THANK YOU

PORTLAND ELECTRIC POWER COMPANY

PLEASE DETACH AND ENCLOSE THIS STUB WITH YOUR REMITTANCE

FINAL BILL

FOR SERVICE TO AMOUNT DUE

YOU HAVE NOT RESPONDED TO OUR PREVIOUS CORRESPONDENCE REGARDING YOUR ACCOUNT WITH US.

CREDIT IS THE MOST VITAL FACTOR IN THE BUSINESS WORLD AND IT IS MANIFESTLY UNFAIR TO YOURSELF AND US, TO NEGLECT AN IMMEDIATE PAYMENT OF THIS ACCOUNT.

WE ACTED IN GOOD FAITH IN EXTENDING THIS FAVOR AND TRUST YOU WILL SHOW YOUR APPRECIATION BY PAYING THE ACCOUNT AT ONCE.

Credit is Based on Confidence—Encourage It

HONESTY FAIRNESS

National Finance Corporation

TRADE MARK

YOURS VERY TRULY,

PORTLAND ELECTRIC POWER COMPANY

PLEASE DETACH AND ENCLOSE THIS STUB WITH YOUR REMITTANCE TO THE

PORTLAND ELECTRIC POWER CO.
329 ALDEN ST. PORTLAND, OREGON

FOR SERVICE TO AMOUNT DUE

YOUR ACCOUNT WITH US IS STILL UNPAID. WE HAVE BEEN VERY LENIENT WITH YOU IN THIS MATTER, BUT NOW WE MUST INSIST ON A SETTLEMENT.

YOU CANNOT AFFORD TO FURTHER NEGLECT PAYMENT OF THIS ACCOUNT WHICH WOULD CREATE THE IMPRESSION THAT YOU ARE TRYING TO EVADE THE PAYMENT OF A JUST DEBT. WE APPEAL TO YOUR SENSE OF FAIRNESS TO RESPOND TO THIS REQUEST AND ELIMINATE THE NECESSITY OF HAVING IT ADJUSTED THROUGH THE NATIONAL FINANCE CORPORATION.

KINDLY GIVE THE MATTER PROMPT ATTENTION.

OUR CREDITS ARE PROTECTED BY

HONESTY FAIRNESS

National Finance Corporation

TRADE MARK

YOURS VERY TRULY,

PORTLAND ELECTRIC POWER COMPANY

PLEASE DETACH AND ENCLOSE THIS STUB WITH YOUR REMITTANCE TO THE

PORTLAND ELECTRIC POWER CO.
329 ALDEN ST. PORTLAND, OREGON

FOR SERVICE TO AMOUNT DUE

Fig. 3. Follow-up notice form, prepared in triplicate

the account, policy of the firm and local and general business conditions. It is obvious, however, that this practice cannot always be followed in the collection of utility accounts where the volume is extensive. It is best, therefore, in preparing letters to consider not thousands of individual cases but rather certain types of collection letters which will serve to cover the general run of accounts.

If, under the stress of detail with thousands of small accounts, one is forced to resort to form letters almost entirely, there is one bit of advice that should be followed. Don't use sets of form letters that others have used. We should make up our own set to apply particularly to our own type of business. If we are using the same form letters as others the strength of the appeal is weakened in proportion to the number of the same kind of letters our customer receives.

The Collector

It is assumed that when an account is handed to the collector for personal contact, the debtor has failed to respond to previous requests for payment, and personal contact is advisable before referring the account to the legal department. It is found that a great many people will respond to a collector's request for payment, but will not pay any attention to correspondence. It is true also that correspondence in many cases is effective where the personal contact has failed. The most difficult job for the collector is locating the consumer who has terminated his business relations with the company and for reasons that may be due to habitual carelessness has failed to give a forwarding address. To make contact with this class it is necessary to make reference to the application and give the collector as much information as possible for his guidance in the location of the debtor.

If the references and credit information have been carefully obtained with a clear conception as to their ultimate usefulness, the problem becomes quite simple as to location. The quality of the references for this purpose determines their future value. Having located the debtor, the question of payment should be stressed as a matter of course and the debtor should be impressed with the importance of settling the account, since failure to do so might affect his credit in future dealings with the company. The closed account should be paid promptly if collection is to be made worth while, since repeated calls quickly absorb the profit.

Legal Steps

If the collection letters and personal calls fail to have any effect on an account, it should be placed in the hands of an attorney. It is best to have an attorney actually in the company employ. However, some utilities prefer a private attorney on a retainer. Whichever plan is used, the debtor should be made to feel that the account is solely in the hands of the attorney and that the creditor has no further control of the account.

The account having been well worked by the time it reaches the attorney, there is no necessity of his writing gentle reminders. He would merely be duplicating the first efforts of the collection department. His first letter should be a clear and concise statement of the facts that there is money owing, that the account has been placed in his hands and that he expects payment.

If through the various channels of legal procedure the attorney is unable to secure payment, the account should be written off, as further work is a waste of time and the results will not compensate for the money and efforts expended.

*Customers' Accounting Methods of the Utah Power & Light Company**

By Gus Anderson

THE Utah Power & Light Company owns and operates electric power and light properties in Utah, southwestern Wyoming, southeastern Idaho, and in addition, owns all the bonds and all the capital stock of the Western Colorado Power Company, which owns and operates electric light and power properties in southwestern Colorado. The Utah Power & Light Company and its Colorado subsidiary serve 281 communities, including Salt Lake City and Ogden, Utah, Durango, Colo., and many rural districts. Total population served is estimated at 450,000.

The territory is divided into ten divisions each having its own commercial office for handling consumers' accounts and reporting to the general offices in Salt Lake City.

The Salt Lake Division covers an area of 800 square miles in Salt Lake County, which includes the cities of Salt Lake, Sandy, Midvale and several small towns, with a total population of 180,000.

Accounting Department Organization

The consumer's accounting department is subdivided into the application, credit, bookkeeping, and billing departments. The application department takes all applications for service and orders to disconnect service, handles all complaints and issues all work orders for the service department. The credit department handles all matters pertaining to the collection of the accounts and passes on all merchandise contracts. The bookkeeping department abstracts the earnings, balances the ledgers, posts credits, opens and closes accounts and compiles all reports. The billing department reads meters, addressographs bills, and posts charges to account cards and bills.

The company's present accounting method is the individual account card system, that is, an account is opened for each meter installed and for large merchandise items, the small merchandise items being entered on a line of the service account.

The Salt Lake Division has 51,000 electric and 5,000 merchandise accounts, divided into 150 ledgers and routed geographically in Salt Lake City and alphabetically in the smaller cities and towns.

Billing

A billing schedule is made each month showing the ledger numbers, meter reading date, billing date and last discount day for each billing district, and all bids are printed from this schedule. They are then addressed by addressograph machine, and previous readings and dates are entered from the ledger cards.

All electric service debits are entered with pen and ink. One group of clerks posts from the meter book to the ledger card the date, reading, consumption and net charge. The meter book then is turned over to another group that enters the present reading, date and consumption on the bills. Rubber stamps are used to extend the gross charges, differences and net charges. The net amount of the bill is compared with the charge on the ledger account and during this operation the

* Report prepared for the customers' records committee.

arrears and merchandise items, if any, are entered on the bill, which then is footed, checked and mailed.

Merchandise charges are posted daily to the ledger cards by a Burroughs duplex adding machine, which recaps by ledgers and gives an automatically accumulated total which must balance with the report made by the sales department.

Final bills are made the same day the disconnect order is received, and if the customer has moved out of town and has a guaranty deposit, the amount of the bills is deducted from the deposit and a check for the balance is mailed to the customer.

An abstract of earnings showing kw.-hr. and amounts for each class of service is made once a month, checked, and the totals posted to the ledger control card.

Cash Receipts

At the time of payment the bills are receipted by a National cash register equipped with a voucher cut-off which stamps the amount paid on both the customer's portion and the cashier's stub, which is cut off during this operation and dropped into the container attached. This machine also accumulates the total of the amounts rung up and gives the amount to which the tellers balance each day, and from which a daily cash statement is made by the tellers, checked and forwarded to the general office.

Stubs taken in are routed according to ledgers and are posted to the accounts the following day by Burroughs duplex machines and recapped by ledgers. The total for the day, which is accumulated automatically, must balance with the amount shown on the daily cash statement.

Ledgers are balanced as of the last day of each month and all debits and credits are posted from the ledger controls to the consumer's ledger summary from which report is made to the general office.

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*Consumers' Accounting With the Hollerith Machine**

By C. F. Kirchhaine

CONSUMERS' accounting on Hollerith machines is accomplished by punching billing information on 80-column Hollerith cards with magnetic duplicator punches. The Hollerith cards are used for printing bills and register sheets.

This article will describe, first, the procedure used by the Puget Sound Power & Light Company, northern district, in installing this system and, second, the operation of the system after installation.

It was decided in the latter part of the month of June, 1929, to install the Hollerith Billing System in the Bellingham office, from which are billed approximately 27,000 electric items and 3,000 gas items each month. The rewriting of the records was begun in the month of July following the closing of the various routes for July business. The new system was placed in operation as of Aug. 1, 1929.

Installation

Meter Reading Sheets—It is necessary to show all billing information on the meter reading sheets for use of the punching clerks. Therefore, two forms of meter reading sheets were prepared. One form, A-91, is used on accounts which require manual calculation because of special contract, and accounts on which the connected load or demand controls the billing. A second form, A-92, is used for all accounts which can be billed from charts indicating extension on kw.-hr. for electricity and cu.ft. for gas. (See Figs. 1 and 2.)

These meter reading sheets were stenciled in the blank space on the bottom after the stencils had been compared for correctness with the present ledgers. Then the billing information was inserted in the appropriate spaces, together with the last reading of the meter. These sheets then were compared with the previous meter reading sheets for the purpose of inserting the location of the meter and arranging them in the exact order the meter reader follows. They were then bound in suitable binders and were ready for use. The new meter reading sheets should be put in use one month before installation of the machine billing, for ease in accounting for final bills.

Register Sheets—A register sheet was devised for showing all information shown on the bills. (See Fig. 3.) The register sheets provide additional spaces for indicating previous balance, total amount due, adjustments, cash posting, unpaid balance forward, and remarks.

Loose-Leaf Binders—Loose-leaf binders were provided for binding the register sheets received each month. A current binder and two transfer binders are provided for each 15,000 items.

Charts for Billing Purposes—Charts for billing purposes were prepared on 18 x 24-in. sheets, using ½-in. rubber stamps, a chart being prepared for each regular schedule controlled by kw.-hr. of current or cu.ft. of gas. These charts were mounted on 19 x 25-in. metal sheets supported on a hinged rack and available for the use of the punching clerks.

Bills—A supply of consumers bills (Fig. 4) were obtained which were designed to indicate the reading dates, schedule under which billed, present reading and previous reading, constant, consumption, demand, amount of bill, class of service, and a stub on which is shown account number, class of service, and amount of bill. These bills must be spaced to fit the printing section of the Hollerith machine.

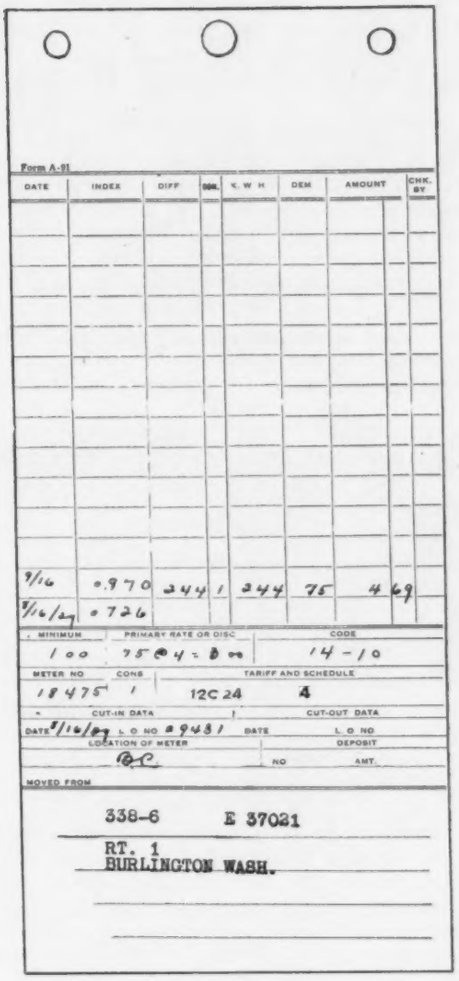
Tickler File—A tickler file was obtained containing an index card for each route in the system to carry information on accounts requiring special attention. (Fig. 5.)

Operation of System

Meter Readings—When the meters are read, a reading must be obtained for each meter in the book as no "skips" can be accounted for. If the meter reader finds that he cannot gain access to the meter for a reading, he estimates the reading, indicating on the meter reading book that this reading is estimated. He leaves at the customer's premises a post card requesting that the customer indicate the reading of the meter on the post card and mail it in for checking the estimate. These post cards are placed in the tickler file and when the bill is prepared on the printing machine the indicated reading from the customer is checked with the estimated reading and if necessary a correct bill is mailed to the customer and adjustment is made.

Checking Meter Books—Meter reading books next are passed to a checking clerk, who checks the subtractions of the readings which were made by the meter readers and extends all readings on accounts requiring manual extension, such as special contracts and accounts controlled by demands. This clerk also removes completed reading sheets due to discontinued accounts after the sheets have served their usefulness.

* Report prepared for the customers' records committee.


Form A-91

DATE	INDEX	DIFF	CODE	K. W. H.	DEM.	AMOUNT	CHK. BY
9/16	0970	244	1	244	75	4 69	
8/16/29	0726						

MINIMUM	PRIMARY RATE OR DISC.	CODE
1 00	75 @ 4 - 5 00	14 - 10

METER NO.	CONS.	TARIFF AND SCHEDULE	
18475	1	12C 24	4

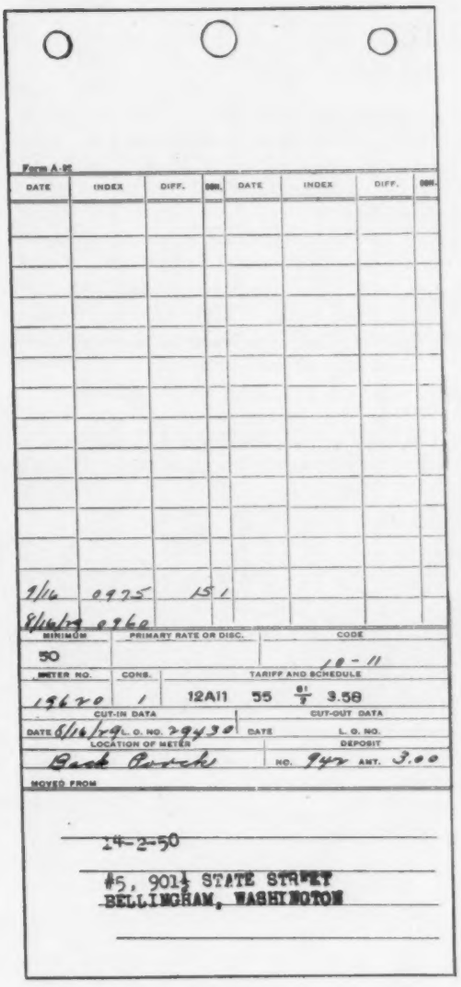
CUT-IN DATA		CUT-OUT DATA	
DATE 8/16/29	L. O. NO. 29481	DATE	L. O. NO.

LOCATION OF METER: DC

DEPOSIT: NO. AMT.

MOVED FROM

338-6 E 37021
RT. 1
BURLINGTON WASH.


Form A-92

DATE	INDEX	DIFF.	CODE	DATE	INDEX	DIFF.	CODE
9/16	0975	151					
8/16/29	0760						

MINIMUM	PRIMARY RATE OR DISC.	CODE
50		10 - 11

METER NO.	CONS.	TARIFF AND SCHEDULE	
19620	1	12A11	55 01/2 3.58

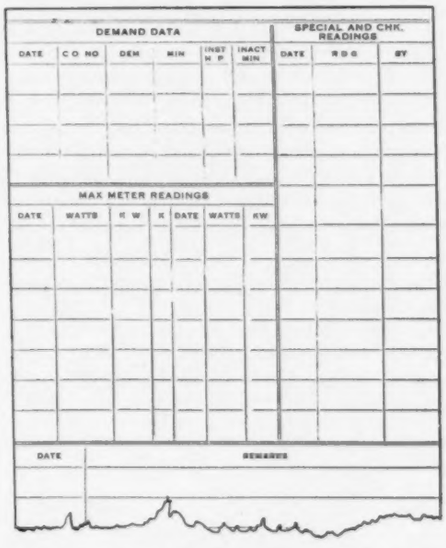
CUT-IN DATA		CUT-OUT DATA	
DATE 8/16/29	L. O. NO. 29430	DATE	L. O. NO.

LOCATION OF METER: Back Porch

DEPOSIT: NO. 942 AMT. 3.00

MOVED FROM

~~14-2-50~~
#5, 901½ STATE STREET
BELLINGHAM, WASHINGTON


DEMAND DATA

DATE	CO NO	DEM	MIN	INST H P	INACT MIN

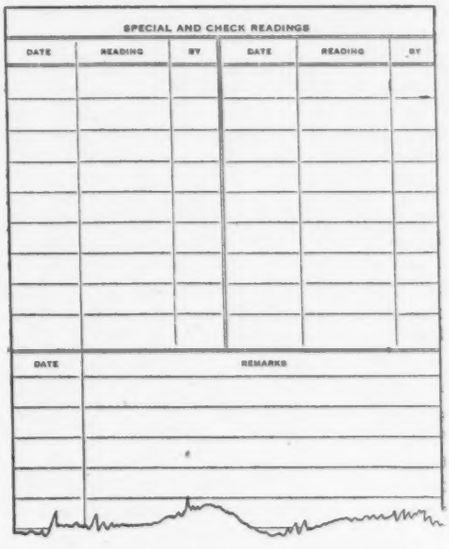
MAX METER READINGS

DATE	WATTS	K W	K	DATE	WATTS	KW

SPECIAL AND CHK. READINGS

DATE	RDG	BY

DATE	REMARKS


SPECIAL AND CHECK READINGS

DATE	READING	BY	DATE	READING	BY

DATE	REMARKS

Fig. 1. Face and reverse of meter reading sheet, Form A-91

Fig. 2. Face and reverse of meter reading sheet, Form A-92

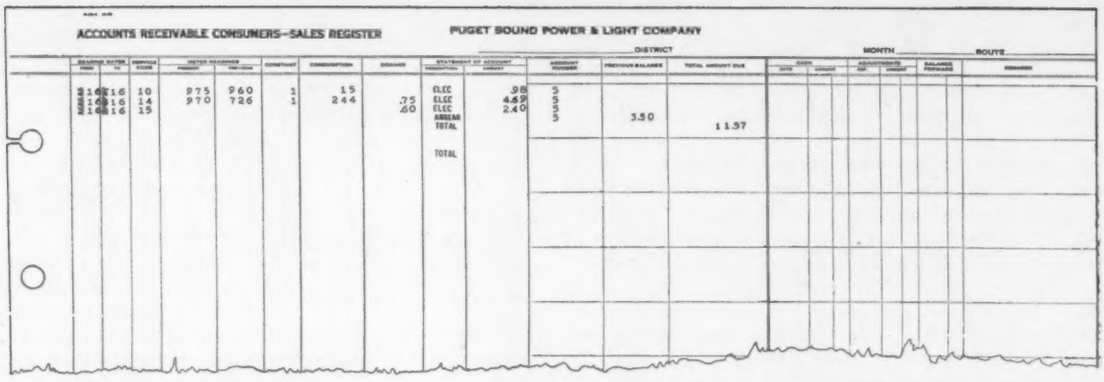


Fig. 3. Register sheet developed to show all information shown on the bills and to provide space for other convenient entries

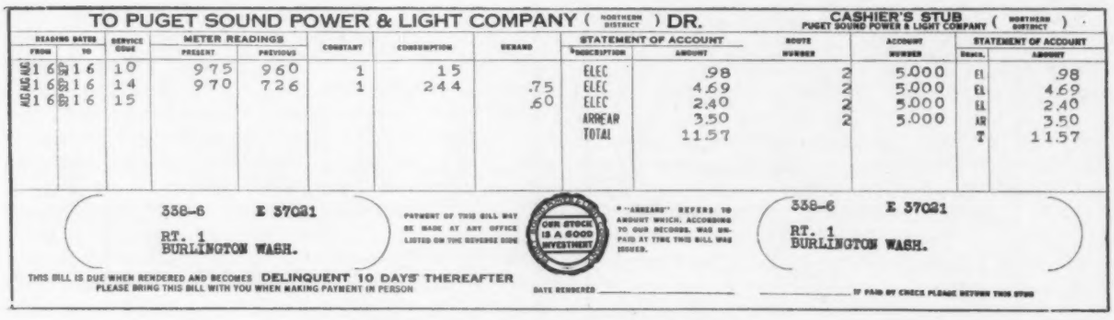

TO PUGET SOUND POWER & LIGHT COMPANY (NORTHERN DISTRICT) DR.
CASHIER'S STUB
PUGET SOUND POWER & LIGHT COMPANY (NORTHERN DISTRICT)
READING DATES FROM TO
SERVICE CODE
METER READINGS PRESENT PREVIOUS
CONSTANT
CONSUMPTION
DEMAND
STATEMENT OF ACCOUNT DESCRIPTION AMOUNT
ROUTE NUMBER
ACCOUNT NUMBER
STATEMENT OF ACCOUNT REMK. AMOUNT
KEWAUNEE
1 16 16 10 975 960 1 15 ELEC .98 2 5.000 El .98
1 16 16 14 970 726 1 244 .75 ELEC 4.69 2 5.000 El 4.69
1 16 16 15 .60 ELEC 2.40 2 5.000 El 2.40
ARREAR 3.50 2 5.000 AR 3.50
TOTAL 11.57 T 11.57
338-6 E 37C21
RT. 1
BURLINGTON WASH.
PAYMENT OF THIS BILL MAY BE MADE AT ANY OFFICE LISTED ON THE REVERSE SIDE
OUR STOCK IS A GOOD INVESTMENT
"ARREARS" REFERS TO AMOUNT WHICH, ACCORDING TO OUR RECORDS, WAS UNPAID AT TIME THIS BILL WAS ISSUED.
338-6 E 37C21
RT. 1
BURLINGTON WASH.
THIS BILL IS DUE WHEN RENDERED AND BECOMES DELINQUENT 10 DAYS THEREAFTER
PLEASE BRING THIS BILL WITH YOU WHEN MAKING PAYMENT IN PERSON
DATE RENDERED
IF PAID BY CHECK PLEASE RETURN THIS STUB

Fig. 4. Specially designed consumers' bills

Punching Cards—The books are passed next to the punching clerks, who punch the billing information on an 80-column Hollerith card. (Fig. 6.) Since some of the billing information will be identical on all the billing cards of a route, a master card is prepared for this common information and placed in the duplicator on the punching machine. This part of the punching is automatic, the punching clerk punching the individual information for each account.

Cycle Balance—A cycle balance is taken for the previous month on each route, on the same day that it is to be punched, for the current month's earnings and arrear cards are punched for all unpaid balances. These cards, together with stenciled bills, are passed to the Hollerith machine for further attention.

Providing Extensions on Cards—Cards first are placed in the sorting machine and all cards for flat accounts and accounts with constants other than one are eliminated. Remaining cards are checked for correct computation of consumption by adding the present readings, the previous readings, and the consumption. The total consumption on a set of cards, added to the total of the previous readings, must equal the total of the present readings. The cards next are sorted to billing schedules and then are checked for correct extension by applying the various steps of the rates under the different schedules to the totals of the kw.-hr. or consumption at the primary, secondary, and third steps. which extension must agree with the total amount of the bills.

It may be well to state at this time that should a customer have two or more meters, the readings of which are to be combined in arriving at the amount of bill on a given schedule, a card is punched for each of the meters, indicating the reading dates, schedule, present and previous reading, constant, and consumption. Then a billing card is punched, indicating the total consumption, demand, and amount of bill, and, if necessary, statistical information relative to amount of discount and consumption in the various steps of the schedule.

Printing Bills—After the cards have been proved to be correct, both as to extension of consumption and amount of bill, they are placed in the sorting machine and are sorted with reference to account numbers and are so arranged in the sorting machine that the lighting schedules will come first, the billing cards referred to in the preceding paragraph following the reading cards where more than one meter is combined on a billing, followed by the power schedules, then the gas, the arrear cards appearing last. Cards then are in order for printing bills and register sheets. These

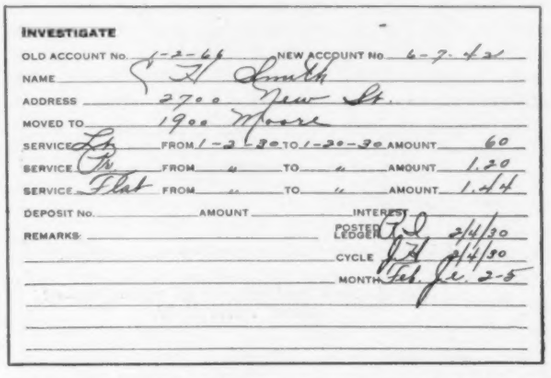

INVESTIGATE
OLD ACCOUNT No. 1-2-64 NEW ACCOUNT No. 6-7-421
NAME C. H. Smith
ADDRESS 2700 New St.
MOVED TO 1900 Moore
SERVICE Lts FROM 1-2-30 TO 1-20-30 AMOUNT 60
SERVICE Pr FROM " TO " AMOUNT 1.20
SERVICE Flat FROM " TO " AMOUNT 1.44
DEPOSIT No. AMOUNT INTEREST
REMARKS POSTED LEDGER 2/4/30
CYCLE 2/4/30
MONTH Feb. Jr. 2-5

Fig. 5. Tickler file index card to carry special information

cards next are checked with the stenciled bills to determine that there is a bill for each customer to be billed.

In addition to this check, the Hollerith operator checks the stenciled account numbers with the account numbers printed by the machine as the bills are being printed.

Printing Register Sheets—By punching a special indication on all the arrear cards and using this indication as a control on the printing machine, the amount on the arrear cards will fall in line with the amount of the billing for current bills and will be totaled on the bill, while on the register sheet the amount of the arrears will be placed in a column separate from the current month's billing, and the total for each customer will be shown in a separate column.

Checking Register Sheets—After the bills and the register sheets are prepared, the meter reading books are checked against the register sheets to see that each indicated account has been properly billed on the correct account number, after which amounts due from the customers for merchandise, jobbing, motor rentals, etc., are entered on the bills by hand. Bills then are mailed out.

Cash Posting—Cash is posted in the column indicated on the register sheets from the stubs received from the cashiers after the stubs have been sorted in numerical order. If the account is paid in full, a rubber dating stamp is used to indicate the fact. If payment on account is made, it is necessary to enter in the date and amount of payment.

Cycle Balance—As stated in a previous paragraph, a cycle balance is taken on each route for the previous month's work after the cash received on the previous day to the billing date has been posted.

Final Bills—Upon receipt of the cut-out line orders,

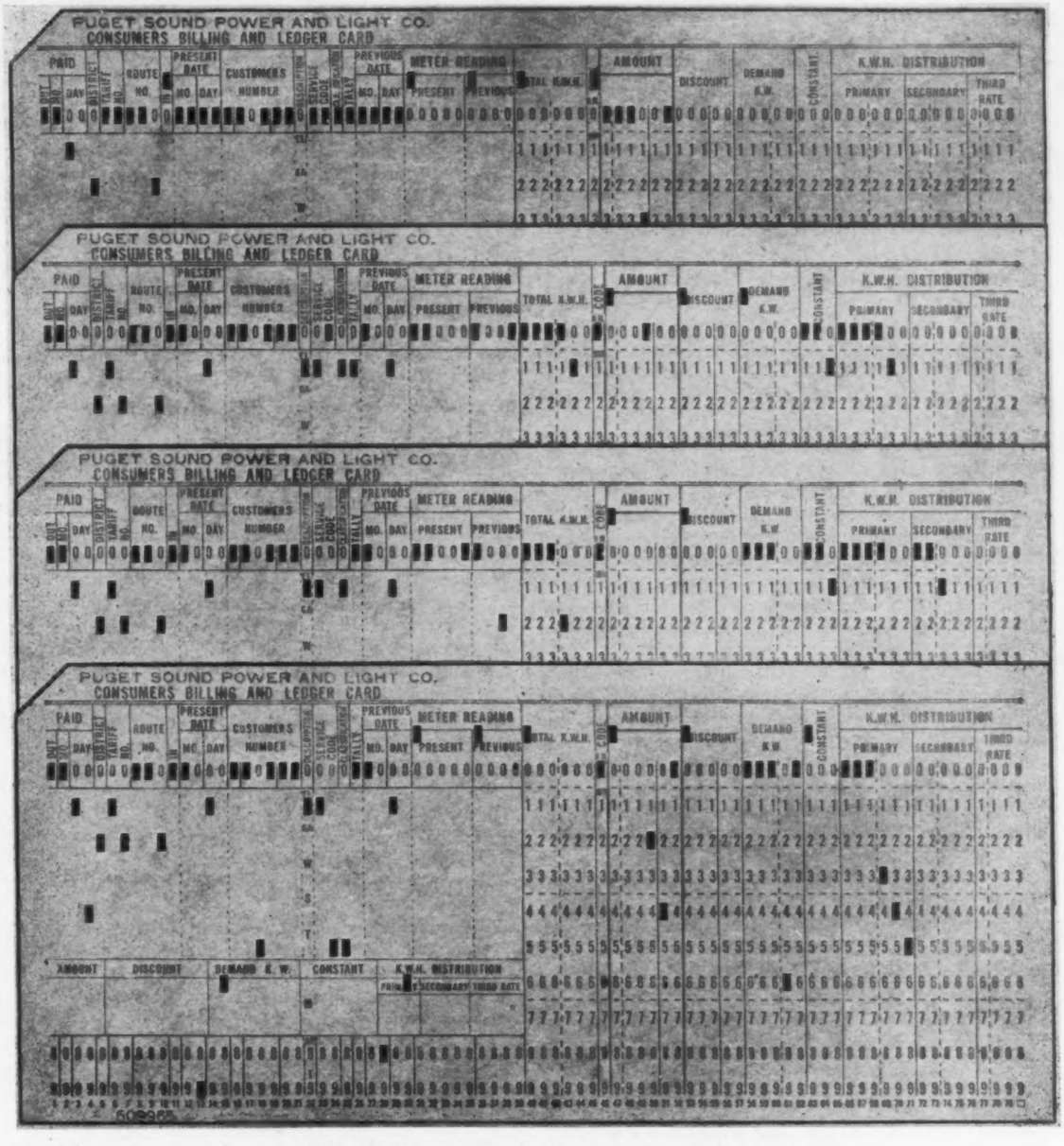


Fig. 6. Set of 80-column cards for Hollerith punching machine

correct account numbers are inserted thereon, stencils are pulled, and bills are printed from the stencils, after which the final bills are prepared and cut-out information inserted on the meter reading sheets affected, indicating thereon date and number of cut-out line order, final reading, the amount of the final bill, the month's earnings affected, also forwarding address of the customer, if any. Notation next is placed in the remarks column on the register sheet of the date of the cut-out, at which time unpaid balances, if any, are inserted on the final bills. Account numbers on the meter reading sheets are revised by adding a suffix "99." This change in account number is put in use as the billing machine controls from the customer's account number.

Meter reading sheets are left in the meter reader's book so that at regular billing date the earning information may be punched by the punching clerk, and since the suffix "99" is indicated on the account number, this information will be registered immediately following the previous account number so that the cut-out bills will not appear on the new customer's account.

In punching the cards for arrears or unpaid balances shown on the register sheets, the suffix "99" is placed on the account number for all unpaid balances on accounts that have been cut out. Should the account be paid the amount on the register sheet, the cash will be posted against the prior month's account, which will result in a credit balance being brought forward to the new register sheet, which will balance the account.

The register sheets are cleared of all these cut out accounts each month prior to cycle-balance time by transferring the unpaid balances to new accounts or the discontinued ledger.

The checking clerk, when checking the meter books against the new register sheets for correctness of machine billing, if the amount remains unpaid at that time, makes notation under "remarks" of the customer's name, the address where service was used, together with the forwarding address for collection purposes.

Opening New Accounts—The procedure for opening new accounts is quite simple. The service department is required to furnish exact information as to the location of the property being served. From this location the customer's account number is arrived at, which is placed on the line order and the necessary forms of meter reading sheets are attached to the line orders. These are passed to the stencil clerk, who cuts the stencil from which the meter reading sheets are printed. After billing information has been inserted they are placed in meter reading books.

Earnings and Statistics—Master cards are punched from each route, indicating the total earnings by the different schedules and statistical information, which, in turn, are used on the Hollerith machine for preparing statement of total earnings for the month. This statement is the basis for a Journal Entry debiting the accounts-receivable consumers and crediting the appropriate earning accounts.

FIXED CAPITAL COMMITTEE

*Definition of a Unit of Fixed Capital**

A Discussion on the Logical Grouping of Detail for Recording in Fixed Capital Records Systems.

THE fixed capital committee for the year ending June, 1930, was charged with the "definition of a unit of fixed capital;" or, more elaborately, the segregation of items of property within accounts into "standard" detail groups for uniform recording in fixed capital records systems.

Fortunately for the committee, this is not entirely a pioneering task, since past committees have given the topic much consideration, and many good systems now are in operation.

The following papers are especially worthy of review in connection with this particular subject:

Fixed capital committee, national section, year 1924; "Suggestion of Major Units for Fixed Capital Accounting."

Fixed capital committee, national section, 1928; "Units for Structure and Contract Construction."

Metropolitan New York section, year 1929 (three separate subcommittees); "General Equipment," "Turbo-Generator Units-Steam," and "Land."

B. S. Rodey, before the Gas and Electric Accounting Society, New York, May 26, 1924; "A Discussion of Fixed Capital Records, Showing the Practice of the United States Electric Light & Power Company, New York."

Scope of Report

This committee has not particularly attempted to develop any new methods or theories of accounting for fixed capital. Rather, it has tried to find a medium somewhere between the two extremes of cumbersome detail and ineffectual brevity which would be of maximum service, contingent with cost, to the average electric utility. It lays no claim to being complete in scope or final in its judgment, realizing full well that if definite and universal rules for the refinement of prescribed accounts were possible to establish now, they could be incorporated in the classification and further research would be unnecessary.

Economy of reconstruction dictates that extensions must be designed to operate with existing equipment. This will continue to retard unification of standards. The Engineering Section of this (Northwest) association, however, through diligent research and exchange of ideas is minimizing the "local condition" factor which sometimes makes the property list of one utility look like a foreign industry to a neighbor in similar pursuit.

The committee believes that with study and periodic revision, while the barrier of both physical and circumstantial dissimilarity is being obliterated, a text for detail subsidiary accounts can be formulated which can be generally prescribed subject to local adaptation. This does not imply that member companies should wait for development in the art. A system after the fashion of any now in use is thoroughly justified.

Definitions

To avoid ambiguity, some of the terms used in this report are defined. These terms are not necessarily

* Report of the fixed capital committee. V. T. Montgomery, Idaho Power Company, chairman. L. E. Hinman, Pacific Northwest Public Service Company, vice-chairman.
Mountain States Power Company: Arch Bezzant.
Pacific Power & Light Company: E. C. Winslow.
Puget Sound Power & Light Company: E. P. Donegan.

meant for adoption, but are selected and defined to avoid confusion in the report itself.

Fixed Capital Records System—Undoubtedly every utility has some method of analyzing and detailing construction costs. The simplest and necessarily the first of these methods is to analyze and detail to some extent the cost of each job upon its completion. For original construction this method is adequate, but after years of additions and removals, the existing detail of a major project or location can not be determined without combining the analyses of all individual jobs into a composite analysis, detailed according to kinds and classes of equipment.

A fixed capital records system as understood in this report, is a system of records which is designed to bring together each kind of property for each geographic location, maintaining at least a perpetual record of cost, quantity, source of origin or reference, and date of acquisition and removal. It may be a part of the books of account, or an entirely independent compilation. It also may show engineering and maintenance data as a marginal reference, depending upon the organization and requirements of individual companies.

Account—An account as referred to here is one of the subdivisions shown in the "Uniform Classification of Accounts for Electric Utilities." It may be a summary account, as "land," or it may be specific, as "hydro-electric power plant land."

Group—A group is a certain general class of property within an account, arranged to facilitate reference, posting, etc. It may consist of nothing more tangible than a thumb-tab followed by ledger sheets or cards upon which detail is posted. In certain accounts, however, where circumstances warrant, group totals may be kept by inserting a ledger sheet or card at the beginning of each group for the purpose of control.

Item—An item represents the maximum detail as to kind, description and individuality designed for recording in a fixed capital records system. Thus, 35-ft. poles in a given location may be an "item" while the only further detail is quantity and average unit cost. For further definition, "item" may be divided into two classes and designated as "individual" and "massed." Individual items are those which are not sufficiently duplicated in kind to permit one general description to suffice for multiple units, or the averaging of prices. Massed items are accumulated according to kind, size, function, average values, etc., and are grouped without regard to individuality of units with total quantities and average unit costs being the governing factors.

Unit—In some discussions "unit" conveys the idea defined as "item." The principal reason for substitution of terminology is that "unit" aptly describes the standard of quantity, such as pound, foot, etc., and would be confusing if used interchangeably. Hereafter in this report "unit" will be understood to be the standard of divisibility within an "item," and will always be associated with quantity.

Summing up the above definitions, an assembly like the following example may be developed:

Fixed Capital Records System—All property at the Water Falls plant.
Account—Electric plant, hydro.
Group—Wire, cable and conduit.
Item—Two-inch metal conduit.
Unit—Linear foot.

Less Elaboration is Desirable

Accepting these definitions for discussion, it may be seen that the most important consideration in planning a fixed capital records system is the selection of items.

A system which simply carries money values by accounts and locations, with references to job numbers and dates, is very easily established and maintained. However, its value is limited because of lack of proper items, the items in this case being expenditure requisitions on work orders. The other extreme, a system which maintains a separate record of each pole and details the fixtures which it supports, it expensive to install and perpetuate, although its uses are unlimited, because of the fineness to which its items have been drawn.

It should be remembered that each refinement, especially in accounts which by nature are voluminous, adds greatly to the burden of perpetuating the system. Conversely, failure to make the refinement may render the system inadequate for many uses, thus necessitating occasionally slow and costly analyses from original records.

As previously stated, no set standard for the amount of elaboration can definitely be advised. A general criterion, however, is that a system, to be effective, should be designed to furnish promptly and without analysis any regularly anticipated information on fixed capital. Seldom, if ever, should it be necessary to go back to individual job cost analyses for information, after the detail has been posted to the fixed capital records system.

Experience seems to tend toward less elaboration, especially in the more active classifications. In accounts involving much detail and relatively small individual amounts, it now is generally conceded that a system which theoretically guarantees the ultimate retirement of all costs and maintains an inventory of major items in quantity and average unit costs is sufficient for most requirements.

Uses of the Records

As fixed capital records systems improve, they are being called upon constantly to furnish information which was not obtainable from former systems. These uses are of such prime importance in designing a system that a partial list is given below, classified according to the sources within the record from which the information usually is taken:

From Detail, or Items:
- Retirements
- Insurance
- Field Inventory Checks
- Depreciation Studies
- Reproduction Cost Studies
- Estimating
- Engineering
- Rate Base Studies
- Federal Power Commission Reports
- Etc.

From Summaries and Controls:
- Insurance
- Budgets
- Regular Reports
- Inventory Summaries
- Statistics
- Taxation Reports
- Various Regulatory Requirements
- Etc.

Recommended Grouping of Detail

It is with the above uses in mind, together with reasonable economy, that the committee recommends the following groups, items, and units. They are arranged according to the Uniform Classifications of Ac-

counts, and may easily be expanded or contracted to meet individual needs.

Organization Account

GROUP	ITEM	UNIT
Original organization cost.		
Increases in capital stock.		
	Each authorization or stock sales program.	
		All.
Other already classifiable items.		

Franchise Account

GROUP	ITEM	UNIT
	County franchises.	
		Each.
	Municipal franchises.	
		Each.

Miscellaneous Intangible Capital Account

GROUP	ITEM	UNIT
(To be determined in each individual case.)		

Land Account

GROUP	ITEM	UNIT
Real land.		
	One continuous tract (including cost of title).	
		Each separately deeded parcel.
Water rights.		
	One power site.	
		Each separate filing.
Leaseholds (if subject to being capitalized).		
	One continuous tract.	
		Each lease or agreement.
Line right-of-way.		
	Easements (including condemnation and legal expenses).	
		All.
	Clearing right-of-way.	
		All.
	Damages.	
		All.

Structures Account

GROUP	ITEM	UNIT
Buildings.		
	Foundations (including excavation).	
		Yard.
	Floors.	
		Square foot, or cubic yard of concrete.
	Exterior walls.	
	Roofs.	
	Interiors.	
	Miscellaneous.	
		Cranes, elevators, heating systems, etc.—each.
Land improvements.		
	Grading, landscaping, bench marks, etc.	
		(To be determined in each individual case.)
	Roads and walks (separate "items" for each depreciation rate).	
	Fences (each kind and type).	
	Water and sewer piping (includes excavation, fittings, etc.).	
		Linear foot.
	Water and sewer equipment.	
		Each tank, pump, motor, etc.
	Miscellaneous structures.	
		Each important individual item.
Local power and lighting system.		
	Poles and fixtures.	
		Each pole.
	Overhead conductors.	
		Pounds of wire.
	Transformers.	
		Each.

Boiler Plant Equipment Account

GROUP	ITEM	UNIT
Boilers and furnaces.		
	Boiler.	
	Furnace.	
	Flue or breeching.	
	Smoke stack or equivalent.	
Boiler room auxiliary.		
	Mechanical stokers.	
	Other mechanical firing equipment.	
	Fuel handling equipment.	
	Ash handling equipment.	
	Feed water pumps.	
	Fuel oil pumps.	
	Economizers.	
	Draft fans.	
	Feed water tanks.	
	Feed water heaters.	
	Feed water filters.	
Piping (each size and kind separately. Cost to include fittings).		
	High-pressure steam piping.	
	Exhaust steam piping.	
	Feed water piping.	
	Circulation piping.	
	Fuel oil piping.	
		Linear foot (all piping).
Miscellaneous.		
	Fuel oil tanks, etc.	
		Each.

Prime Movers and Auxiliaries (Steam) Account

GROUP	ITEM	UNIT
Steam engines or turbines.		
	Engine or turbine.	
	Foundations.	
Condensers.		
	Condensers.	
	Pumps.	
Condensing water cooling systems.		
	Towers.	
	Sprays.	
	Piping.	
Miscellaneous.		
	Each miscellaneous item worthy of separate treatment.	

Turbine-Generator Units (Steam) Account

(Same as preceding account, except that generators are included with prime movers.)

Electric Plant (Steam) Account

GROUP	ITEM	UNIT
Generators.		
	Generators.	
	Foundations.	
		Each.
Exciters.		
	Exciters.	
	Foundations.	
		Each.
Air washers		
	Air washers.	
	Pumps.	
		Each.
	Air washer piping (by sizes).	
		Linear foot.
Field rheostats.		
	Each general type.	
Power and control motors.		
	Each type and size.	
Switchboards.		
	Each size and kind.	
Switchboard instruments.		
	Each type of instrument.	
Oil circuit breakers.		
	Each type and size.	
Station service transformers.		
	Each size and type.	
Instrument transformers.		
	Each type and size.	

Electric Plant (Steam) Account (Continued)

GROUP ITEM UNIT

Compensators.
Each type.
Wire, cable and conduit.
Each size, kind, voltage, etc.
Linear foot (cost includes incidentals).
Control battery.
Battery.
Rack.
Charging set.
Lightning arresters.
Each general type.
Miscellaneous.
Bus and switch compartments, etc.
Each.

Miscellaneous Power Plant Equipment (Steam) Account

GROUP ITEM UNIT

Counter shafting.
Each size.
Linear foot.
Belting.
Each kind and size.
Linear foot.
Pulleys.
Each kind and size.
Major machine tools.
Locomotives, cars, and cranes.
Small tools.

Reservoirs, Dams, and Waterways Account

GROUP ITEM UNIT

Preparatory work.
Preliminary investigation.
Clearing pond area.
Clearing dam site
Excavation and backfill.
Yard (if available).
Dam proper.
Concrete.
Yard.
Apron.
Concrete.
Yard.
Gates and operating mechanism.
Steel.
Pound.
Raising and lowering mechanism.
Each assembly.
Motors
Each.
Screens and trash racks.
Each assembly.
Pound of steel.
Stop-logs and flashboards.
Stop-logs.
Flashboards.
Board-foot.
Fish ladders.
Wooden fish ladders.
Concrete fish ladders.
Each, cubic yard, or board foot.

Navigation Facilities Account

(To be determined by requirements in each individual case)

Waterways Account

GROUP ITEM UNIT

Preparatory work.
Clearing right-of-way.
Excavation and backfill.
Yard (if available).
Foundations or saddles for flow line.
Each.
Yard.

Navigation Facilities Account (Continued)

GROUP ITEM UNIT

Canals, flumes, and ditches.
Excavation.
Yard.
Lining.
Yard.
Tunnels.
Each.
Linear foot.
Bridges.
Each bridge.
Each.
Valves.
Each valve.
Each.
Pipe line.
Each size.
Linear foot.
Control equipment.
Each major item.
(To be determined by nature of equipment.)
Miscellaneous structures.
Each structure.
Each.

Forebays, Penstocks, and Tailraces Account

GROUP ITEM UNIT

Preparatory work.
Clearing land.
Excavation and diking.
Cubic yard.
Penstocks.
Saddles or anchors.
Valves.
Structures.
Envelopes or coverings.
Miscellaneous.
Surge tanks.
Clearing land.
Excavation.
Foundations.
Concrete structures.
Miscellaneous (determine individually).
Tailrace.
Excavation.
Yard (if available).
Concrete.
Yard.

Roads, Trails, and Bridges Account

GROUP ITEM UNIT

Automobile roads.
Right-of-way.
Grading and drainage.
Surfacing (each kind).
Mile or linear foot.
Bridges and culverts.
Each.
Railroads.
(Companies maintaining extensive railroads as a secondary operation will find the Interstate Commerce Commission classification convenient.)

Water Turbines and Waterwheels Account

GROUP ITEM UNIT

Turbine units.
Turbines.
Runners.
Foundations.
Governors.
Each governor.
Valves.
Penstock valves.
Relief valves.
Draft tubes.
Each.

Water Turbines and Waterwheels Account (Continued)

GROUP	ITEM	UNIT
Oil pressure system.		
	Compressors.	
	Tanks.	
	Motors.	
Piping system.		
	Each kind and size.	
		Linear foot (cost includes fittings).
Special hydro-static apparatus.		
	Each.	

Turbine-Generator Units (Hydro) Account

(Same as preceding account, except that generators are included with turbines.)

Electric Plant (Hydro) Account

GROUP	ITEM	UNIT
Main generators, including direct-connected exciters.		
	Generators.	
	Foundations.	
	Auxiliary exciters.	
	Foundations.	
Air washers.		
	Air washers.	
	Pumps.	
	Piping (by sizes).	
		Linear foot.
Field rheostats.		
	Each general type.	
Power and control motors.		
	Each type and size.	
Switchboards.		
	Each size and kind.	
Switchboard instruments.		
	Each type of instrument.	
Oil circuit breakers.		
	Each type and size.	
Air circuit breakers.		
	Each type and size.	
Disconnecting switches.		
	Each type and size.	
Instrument transformers.		
	Each type and size.	
Station service transformers.		
	Each type and size.	
Compensators.		
	Each type and size.	
Wire, cable, and conduit.		
	Each size and kind.	
		Linear foot (cost includes all fittings).
Buses.		
	Conductors, by sizes.	
		Linear foot.
Supporting structures.		
	Each structure.	
Control battery.		
	Battery.	
	Rack.	
	Charging set.	
Lightning arresters.		
	Each general type.	
Miscellaneous.		
	Bus and switch compartments, etc.	
		Each.

Miscellaneous Power Plant Equipment (Hydro) Account

GROUP	ITEM	UNIT
Counter shafting.		
	Each size.	
		Linear foot.
Belting.		
	Each kind and size.	
		Linear foot.
Pulleys.		
	Each kind and size.	
Major machine tools.		
Locomotives, cars, and cranes.		
Small tools.		

Fuel Holders, Producers, and Accessories (Gas) Account

GROUP	ITEM	UNIT
Boiler plant equipment (see boiler plant equipment—steam)		
Steam engines (see prime movers and auxiliaries—steam)		
Benches and retorts.		
	Each.	
Holders.		
	Each.	
Purification apparatus.		
	Each major item.	
Oil storage tanks.		
	Each tank.	
Oil supply lines.		
	Piping by sizes.	
		Linear foot.
Oil pumps.		
	Each size and type.	
Piping.		
	Each size and kind.	
		Linear foot.
Special foundations.		
	Each foundation.	
		Cubic yard.
Laboratory equipment.		
	Each major item.	

Internal Combustion Engines Account

GROUP	ITEM	UNIT
	Engines.	
	Major auxiliary items.	
	Special foundations.	

Electric Plant (Gas) Account

(See electric plant—steam.)

Miscellaneous Power Plant Equipment (Gas) Account

(See miscellaneous power plant equipment—steam.)

Substation Equipment Account

GROUP	ITEM	UNIT
Outdoor structures.		
	Foundations.	
	Timber structures.	
	Steel structures.	
		Each foundation or structure.
	Equipment fences.	
		Rod.
Power transformers.		
	Each transformer.	
Constant current transformers.		
	Each.	
Arc rectifiers.		
	Each.	
Voltage regulators.		
	Each.	
Motor-generator sets.		
	Each.	
Rotary converters.		
	Each.	
Synchronous condensers.		
	Each.	
Lightning arresters.		
	Each set.	
Reactors.		
	Each.	
High-voltage switches.		
	Each set.	
Current and potential transformers.		
	Each set.	
Switchboards.		
	Each kind and size.	
Switchboard instruments.		
	Each size and type.	
		Each.
Instrument transformers.		
	Each size and type.	
		Each.
Disconnecting switches.		
	Each type and size.	
		Each.

Miscellaneous Power Equipment (Gas) Account (Continued)

GROUP ITEM UNIT

Wire, cable, and conduit.
Each kind, size, and voltage.
Linear foot (cost includes potheads and fittings).

Control battery.
Battery.
Rack.
Charging set.

Local service transformers.
Each size and voltage.
Each.

Miscellaneous substation equipment.
Bus and switch compartments, etc.

NOTE—All specially provided foundations should be included in a separate "item" immediately associated with the equipment for which designed.

Storage Battery Equipment Account

GROUP ITEM UNIT

Batteries.
Each.

Racks.
Each.

Motor-generator sets.
Motor-generators.
Foundations.

Specially constructed floors.

Miscellaneous.
Each major accessory.

Underground Conduits Account

GROUP ITEM UNIT

Manholes.
Each general size and type of construction.
Each (or cubic foot of volume may be used as unit).

Vaults.
Each general size and type.
Each.

Subways (including excavation and conduit).
Each kind and size of conduit.
Linear foot.

NOTE—Repaving may be included in cost of manholes and subways.

Poles, Towers, and Fixtures Account

GROUP ITEM UNIT

Poles (including pole supports, conductor supports, etc.)
Each pole length.
Each pole.
or, in lieu of the foregoing

Poles (including pole supports, conductor supports, etc.)
All.
Pole foot (linear).
or, in lieu of the foregoing

Poles and fixtures.
Poles.
Pole foot (linear).
Pole supports.
Each anchor (including cost of span guys, etc.).
Conductor and equipment supports.
Board foot (including pins, hardware, etc.).

Steel towers.
Each type.
Each.

Overhead Conductors Account

GROUP ITEM UNIT

Conductor.
Each kind and size.
Pound or linear foot.

Overhead Conductors Account (Continued)

GROUP ITEM UNIT

Pin-type insulators.
Each voltage.
Each.

Strain insulators.
Each size and type (clevis, ball-and-socket, etc.).
Each.

Line devices.
Each kind, general type, and size.
Each.

Underground Conductors Account

GROUP ITEM UNIT

Conductor.
Each kind, size, and voltage.
Linear foot.

Junction boxes.
Each size.
Each.

Terminals or potheads.
Each type and size.
Each.

Transmission Roads and Trails Account

(See roads, trails, and bridges.

Services Account

GROUP ITEM UNIT

Each size and number of wires.
Each.
or in lieu of the foregoing.

Each service (regardless of size and number of wires).
Each.

Line Transformers and Devices Account

GROUP ITEM UNIT

Transformers.
Each specific size and rating.
Each.

Cutouts.
Each make and rating (not including plug type formerly included in cost of transformers).
Each.

Line Transformer Installation Account

GROUP ITEM UNIT

Overhead installations.
Each size in kva.
Each.

Underground installations.
Each size in kva.
Each.

NOTE—This account may be simplified greatly by combining sizes into a few inclusive groups of kva. ratings, or it may be practical in some instances to ignore sizes altogether. Transformer installation costs usually are not associated with individual transformers, but rather with transformer locations.

Consumers' Meters Account

GROUP ITEM UNIT

Meters.
Each type and rating.
Each.

Instrument transformers.
Each kind, and specific rating.
Each.

Meter Installation Account

GROUP — ITEM — UNIT

Meter installation.
Each.

Power meter installation (involving instrument transformers).
Each.

Installations on Consumers' Premises Account

GROUP — ITEM — UNIT

Each specific location.
Motors.
Each.
Generators.
Each.
Motor-generator sets.
Each.
Frequency chargers.
Each.
Panels.
Each.
Control equipment.
Each major item.
Wire, cable, and conduit (by kinds and sizes).
Linear foot.

Commercial Lamps Account

GROUP — ITEM — UNIT

All complete installations.
Each.

Street Lighting Equipment Account

GROUP — ITEM — UNIT

*Constant current transformers.
Each specific size and type.
*Special transformers.
Each specific size and type.
*Circuit breakers.
Each specific size and type.
*Time switches.
Each specific size and type.
*Station wire, cable, and conduit.
Each size and kind.
Linear foot.
*Switchboards.
Each size and kind.
Each.
*Metering equipment.
Each size and kind.
Each.
Arc lamp installations.
Each type.
Each.
Incandescent units.
Each type.
Each.
Ornamental lamp posts.
Each type.
Each.
*Specially provided poles.
Each pole length.
Each pole.

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* If not in conflict with regulatory authority, this equipment may more conveniently be carried under other appropriate accounts.

Electric Appliances Account

GROUP — ITEM — UNIT

Each readily identifiable item.
Each.

Office Equipment Account

GROUP — ITEM — UNIT

Furniture and furnishings.
Desks and tables.
Each (preferably by company numbers).

Office Equipment Account (Continued)

GROUP — ITEM — UNIT

Chairs.
Each.
Lockers and booths (by common descriptions)
Each.
Floor coverings.
Square yard, or each.
Clocks.
Each.
Fans (by sizes).
Each.
Lighting fixtures (removable, in leased buildings).
Each make or class (by company and manufacturer's number).
Each.
Garage and shop equipment.
(Each major item by individual identification.)
Machines (each by manufacturer's serial number).
Typewriters.
Adding machines.
Calculators.
Filing equipment.
Cabinets (by specific descriptions).
Movable safes.
Miscellaneous.
Chronograph systems.
Pneumatic tube systems.
Lunch room equipment.
Doctors' and first aid equipment.

Stores Equipment Account

Shop Equipment Account

(Each major item by individual identification.)

Transportation Equipment Account

GROUP — ITEM — UNIT

Automobiles.
Each major item by individual identification.
Each.

Telephone, Telegraph, and Wireless System Account

GROUP — ITEM — UNIT

Telephone and telegraph lines.
Poles and fixtures (see transmission and distribution).
Overhead conductors (see transmission and distribution).
Telephone equipment.
Wall and desk sets.
Each.
Switchboards, complete.
Each.
Drainage transformers.
Each.
Relays (including relay boxes).
Each.
Miscellaneous.
Each major item.
Telegraph equipment.
Major items by individual identification.
Each.
Carrier current equipment.
Each major item.
Antenna towers.
Each tower.

Laboratory Equipment Account

(To be determined in each individual case.)

Miscellaneous Equipment Account

(To be determined in each individual case.)

PURCHASING AND STOREROOM COMMITTEE

*Storeroom Methods**

THE report of the purchasing and storeroom committee consists of two subjects related to storeroom methods as follows:

Method of handling and recording robbed parts from appliances and equipment.

Perpetual plan for inventory and the advantages to be gained over the annual plan.

These are presented herewith.

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* Report of the purchasing and storeroom committee. W. L. Fitzpatrick, Mountain States Power Company, chairman.
Idaho Power Company: I. E. Joslyn.
Mountain States Power Company: Harry Anderson.
Northwestern Electric Company: W. M. Adam.
Pacific Northwest Public Service Company: I. D. Murfield.
Pacific Power & Light Company: H. M. Dunkelberger.
Puget Sound Power & Light Company: H. B. Johnson.
Utah Power & Light Company: Henry Mann.

*Handling and Recording Parts "Robbed" From Appliances and Equipment**

THE handling and recording of parts "Robbed" from appliances and equipment is purely an emergency problem dealing with appliances or equipment for which no provision has been made in regard to stocking spare parts in the warehouse. The following method has proved to be quite satisfactory in such cases:

The article wanted must be covered in the regular manner by a storeroom requisition originating in the department requesting the article, giving the correct description and the proper account to be charged. This requisition must be signed by the department head for authority. The storekeeper, upon receipt of the requisition, will rob the complete unit furnishing the part wanted and immediately request the balance-of-stores department to re-order, giving the correct description as furnished by the requisition and the symbol of the complete unit, to which the part will be charged.

The balance-of-stores department will place an order on the purchasing department, which in turn will order the part in the usual manner from the firm which supplies such parts. Upon receipt of a copy of the purchase order, the storekeeper will file the order alphabetically under the vendor's name, attaching the requisition to the order pending the arrival of the article.

Upon the arrival of the article from the factory, the storekeeper will re-assemble the robbed unit, making it again complete. He then will make out a receipt-of-material form and forward it to the balance-of-stores department, together with the storeroom requisition. The balance-of-stores department will enter the receipt of material on the stock card and forward the card to the purchasing department. The requisition remains attached to the stock card, awaiting the invoice. Upon receipt of the invoice by the purchasing department, the receipt of material is attached and forwarded to the balance-of-stores department for posting the money value on the stock card. The requisition then is priced and passed in the usual manner.

Under this method, everyone interested in the transaction has a record and the ordering is done by the stores department. Furthermore, the supporting record of authority is always on file. This again shows the importance of the single-item requisition in solving the various problems that arise.

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*A report of the purchasing and storeroom committee.

*Perpetual Plan of Inventory and Its Advantages Over the Annual Plan**

IT IS a well-known and old established practice among commercial houses and retail stores dealing directly with the public to set a date once each year to take a physical check of the stock on hand and make the necessary adjustment of the records and reconcile the general ledger in terms of money value to agree with the inventory.

Annual Plan

To take an inventory on the annual plan requires the actual suspension of business temporarily. Often the time required amounts to as much as one or two days for smaller organizations and in some cases may require a week or more to accomplish. The annual plan necessarily requires a much larger force of people in order that the work may be finished in the shortest time possible to permit early re-opening of the store for general business.

While the annual plan perhaps is more adaptable to retail stores and lines of business dealing with the public, much can be said unfavorable to this plan when applied to the larger institutions, such as railroads, power companies and others carrying large stocks in their warehouses for their own requirements. It may be appreciated readily, how, under the annual plan of inventory, the regular work in progress would be affected by closing down the storeroom for a week or more to take an inventory. In this day of progress, time is money and consequently more modern methods are necessary to carry on the work with the least amount of interference possible. For this reason alone the annual plan is more or less antiquated. The annual plan also has a tendency to create carelessness among the stock clerks in the storerooms, and in some cases even leads to the pilfering of stock.

In brief, the length of time between inventories has a decided detrimental effect upon the personnel handling the stock and the character of the work performed.

Perpetual Plan

Accurate stock records are indispensable in good storekeeping. Poor records breed carelessness and permit an element of guesswork to creep in which should not exist. Therefore, it is essential, when making preparations for the perpetual plan of inventory, to be sure that a record is set up which will give complete data on any article from the time of placing the order for purchase until the article actually is dispensed from the storeroom. The stock card, which is the most acceptable form of record and perhaps the most commonly used, should be very carefully planned to give the required information. A comprehensive stock card should give the following information:

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*A report of the purchasing and storeroom committee.

Complete description of the article
Storeroom number in which article is stored
Reference for responsibility
Symbol or lot number
Date of ordering
Date of purchase order
Purchase order number
Vendor's name
Date of receipt
Amount vendor's invoice
Freight and cartage
Total cost
Unit cost
Date issued
Quantity issued
Quantity returned for credit
Amount charged or credited
Amount in money value
Balance on hand

The balance on hand after each transaction, whether incoming or outgoing, has a decidedly important part to play in keeping an accurate record. Housing of the material is another important factor, and careful planning also should be exercised to see that all items of like nature, or items pertaining to special groups, such as railway electrical material, are stored in a certain section of the warehouse and the section numbered with bin tags on each bin, giving the following information:

Correct name and description of article
Symbol or lot number assigned
Date received
Date issued
Quantity in units
Account chargeable or credited

Under this arrangement, clerks in the warehouse soon become familiar with the various locations of the stock and much time will be saved in the filling of orders. The clerk filling the requisitions knows at a glance where to find the material wanted and removes the amount called for from the bin. At the same time he posts the quantity on the bin tag, makes the subtraction and brings down the new balance. This new balance also is placed on the requisition in the space provided and the clerk then signs his initial on the requisition to show who filled it. Initialing of the requisition by the clerk in his own handwriting places the responsibility directly upon him and has a moral effect, keeping the clerk constantly on the alert to avoid making errors, which in turn improves and builds up the standard of the work performed by the clerks to a higher degree of efficiency, all of which has much bearing on the inventory.

Another feature that plays a very important part in the success of the balance-on-hand system, or perhaps more commonly known as the balance-of-stores system, is the use of single-item requisitions, transfers, credit memos, receipts, and, in fact, all transactions affecting the balances. Each transaction covering withdrawals from the stock or additions to the stock, if made out on individual requisitions, will give the greatest amount of flexibility possible to attain, and while the extra paper required may seem quite unnecessary, it will be found, however, that the efficiency gained far more than compensates for the paper used.

The single-item requisition, carrying the balance-on-hand feature, permits an inventory to be taken on any item selected at any time desired. The requisition also can be used as an order on the purchasing department as authority for buying the material and delivering directly to the job, in cases where the storeroom is unable to fill the order. This is done either by stamping or writing across the face of the requisition, "goods on purchasing department," which immediately converts the requisition into an order on the purchasing department. In brief, the single-item requisition makes it possible to make a study of any item without conflicting with, or holding up, the regular routine of any other item. Perpetual inventory, with the supporting records as mentioned, will prove far more successful and beneficial in many ways than the annual plan.

Advantages of Perpetual Plan

Some of the outstanding features in favor of the perpetual plan of inventory, as compared with the annual plan, are that the perpetual plan—

Allows a closer supervision of the stock,

Improves the efficiency of the work performed by the clerks in the warehouse thereby raising the standard,

Requires a smaller force to make an inventory,

Makes it possible to count material at any time desired,

Allows for a complete inventory, or special group, or an individual item only,

Spreads the adjustments over the entire year's business on a monthly basis, and

Has a decided tendency to overcome obsolescence.

Last, but not least, it has much to do with the financial structure, holding the stock down to a minimum consistent with the operations of the company.

GENERAL RECORDS COMMITTEE

*Machines for General Records**

DURING the year 1929-30 the general records committee studied the advisability and practicability of the use of machines for general records, and the question of defining the point of efficiency between machine and handposting of general records.

The question of the propriety of machine bookkeeping is beyond argument. During the last twenty years all kinds of mechanical devices have invaded the accounting office until today, at least in this country, an office without machinery is almost as antiquated as a ship without engines. The advisability of the use of machinery in any accounting feature is decided primarily by the consideration of three factors: cost, speed, and form of record produced. It is conceded that the application of machines in some form to customers' accounts receivable will result in a reduction of cost, additional speed, and a satisfactory form of record, for the reason that customers' accounts, in a utility of any size, are voluminous enough to warrant a machine installation of some type. This is not true in regard to the general records of utilities. The variety of these records due to local conditions demands that each feature be

* Report of the general records committee. G. F. MacKenzie, Pacific Power & Light Company, chairman. C. E. Gieseker, The Washington Water Power Company, vice-chairman.
The California Oregon Power Company: R. B. Smith.
Mountain States Power Company: John Ford.
Pacific Northwest Public Service Company: E. I. Snyder.
Puget Sound Power & Light Company: F. H. Anderson.

considered by itself and in relation to the other records on which it depends. It is not possible to single out even one feature of the general records and say definitely that it could satisfactorily be handled by means of machines. The most that can be done is to present the features of some machine installations which have proved themselves under actual operating conditions, with the hope that an idea may be procured which may be of help in solving some general record accounting problem. The committee therefore is submitting in conjunction with this report (1) the outline of an installation of the Moon Hopkins machine (Burroughs Adding Machine Company) applied to accounts payable and (2) a discussion of machines applied to cost accounting. These articles may be found on the pages immediately following this report.

No Rule Can Be Formulated

It is the opinion of the committee that it is impossible to formulate any rule to define the point of efficiency between machine and hand posting methods. It would be wrong even to state that the magnitude of a particular accounting feature has any bearing on the question for some of the most valuable time-saving installations come as by-products of machines used for other purposes. Particularly is this true in connection with the tabulating machines known as the Hollerith and the Powers, and to those companies fortunate enough to possess an installation of this type many valuable by-products accrue in relation to general records. In this connection it is repeated that each problem must be considered by itself and in the light of all the conditions surrounding it. Conditions such as geographic distribution of territory served, management policy, type of superintendence and many others have a bearing on each case and reflect themselves in even the simplest operation relating to general records.

No substantial benefit seems to be derived from keeping the general ledger by machine methods. The Detroit Edison Company, which probably is one of the most highly developed machine accounting utilities in the country and a company which serves more than 500,000 customers, reports that "The general ledger is for the most part a pen-and-ink record, although typewriters are used where possible." Therefore, it is the opinion of the committee that the general ledger is not a record which lends itself to machine accounting.

Bibliography

During the investigation of this question several pamphlets were received by the committee from the National Electric Light Association. These undoubtedly would be of interest to any utility considering the question of machine bookkeeping. These may be had upon application to the N.E.L.A.:

* General Office Machine Accounting System of Public Utilities, presented by the American Gas & Electric Company.

Development of Customers' Accounting Machines, N.E.L.A. customers records committee report 1928-29.

System for Receiving, Recording and Refunding Customers' Deposits, N.E.L.A. customers records committee 1926-27.

Guide Covering Use of Machines on Accounting Work, the Detroit Edison Company.

The development of accounting machinery has been so rapid and the subject is of such vital importance to the Northwest Accounting Section that the committee believes it would be advisable to include in the program of the Accounting Section each year a committee assignment which would assure adequate contact with machine development both from the mechanical and the application standpoint.

Co-operation With National Committee

During the year this committee co-operated with the general records committee of the N.E.L.A. in an investigation of the preservation and destruction of records, to the extent of reporting methods employed by local companies. A request recently has been received from this committee for material relating to machine bookkeeping suitable for inclusion in the exhibit section of the N.E.L.A. Convention to be held in San Francisco in June. The committee has forwarded all available material.

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*Unit Posting Slip Plan for Posting Invoices**

By B. H. Parkinson

AN author in describing the principle of a ledger account gave as a definition of a ledger account, ". . . a record wherein like facts may be brought together in one place, prior to the time they are needed for making a balance sheet," and went on to say that "what is needed is a sort of pigeon-hole device into which the facts of changing financial conditions may be sorted. This cannot be done directly, like building a mail-sorting rack in a post office, for the facts accounting has to 'sort' are not tangible things like letters, to be thrown into sacks or bins. Accounting facts are ideas, or rather figure symbols of ideas. Therefore, a record is needed more than a 'rack'." Obviously a practicable plan which would make possible the sorting of accounting facts into their ultimate classification by using a pigeon-hole device or other physical means would save considerable time and expense. Such a plan has proved to be practicable and may be termed the "Unit Plan."

The unit plan of accounting is not entirely new. However, the idea of applying the principle as completely as possible in designing all accounting systems is comparatively new, i.e., in the first operation reduce the original data to their smallest unit; second, physically sort the items into their ultimate classification; and third, enter in detail or mechanically tabulate and enter in total in the final distribution record.

The degree of success with which mechanical sorting and tabulating devices are used in connection with the unit plan of accounting is commonly known. Whether to sort mechanically or by hand is a question of expense and depends entirely upon the number of different tabulations of the same media that are to be made and also upon the volume, the load factor that can be developed for the sorting machine, and whether the posting unit is developed as a by-product or is a factor of expense. There is another factor which is entirely in favor of the hand plan because of the nature of the unit produced (i.e., in writing rather than a punched card) and that is that the posting unit after tabulation may be used as a ready analysis of the total, or, as in the case of construction accounting, permanent supporting detail.

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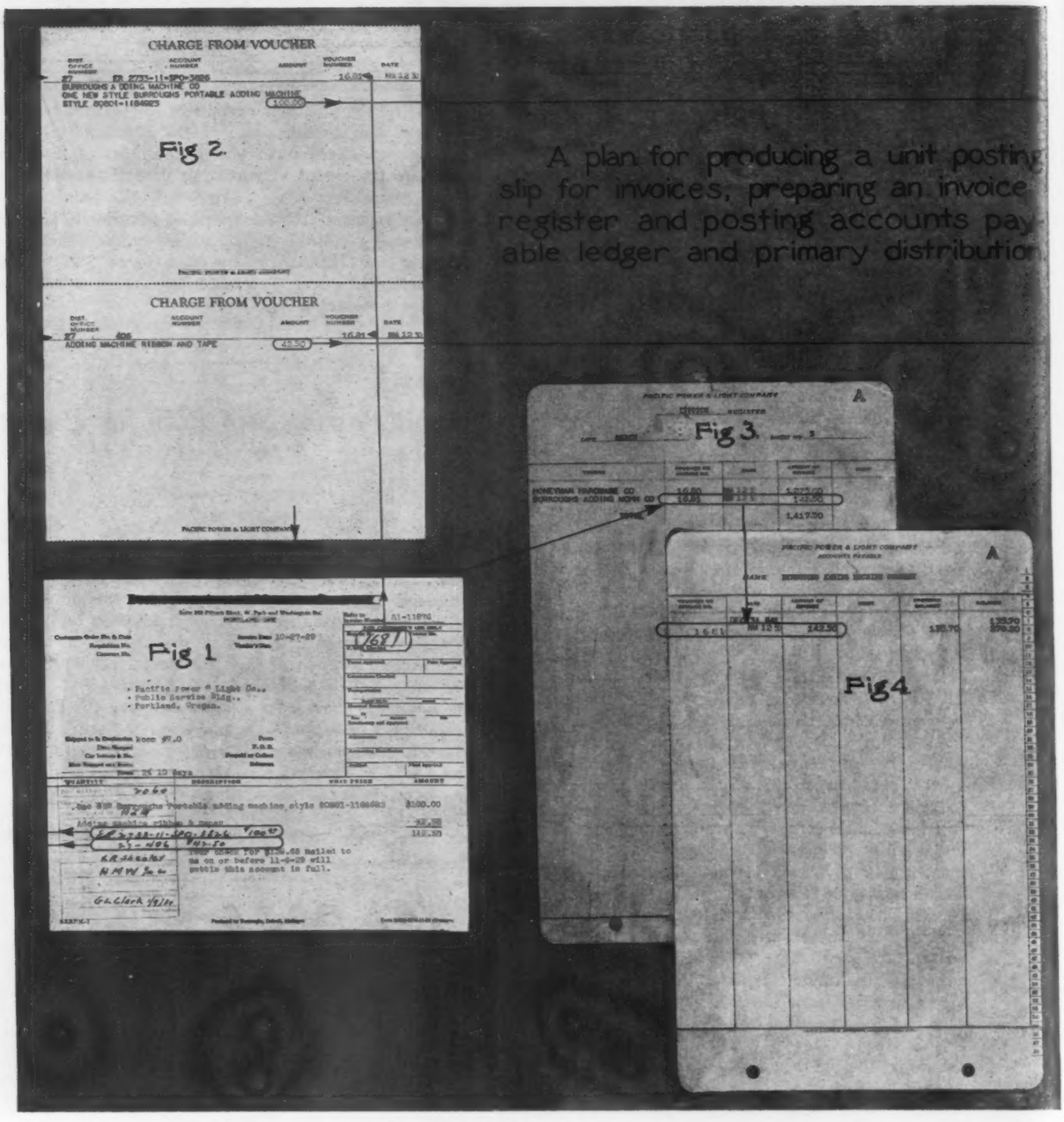
* Supplement No. 1 to the report of the general records committee.


CHARGE FROM VOUCHER
Fig 2.
CHARGE FROM VOUCHER
A plan for producing a unit posting slip for invoices, preparing an invoice register and posting accounts payable ledger and primary distribution
Fig 3.
Fig 1
Fig4

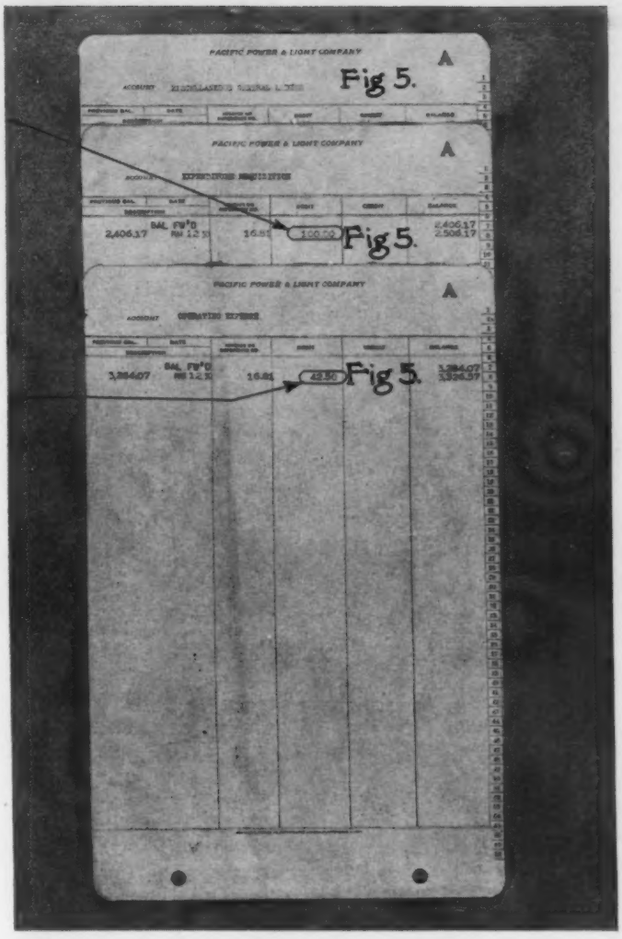
The unit posting slip plan

In connection with the unit plan where sorting is to be done by hand, the time ticket, whether for an individual or a crew, is designed in duplicate in such a way that the duplicate can be cut into units. Storeroom orders are drawn in duplicate with a separate requisition for each expense charge, and the duplicate becomes the posting unit. A separate cartage or transportation order is drawn for each charge account. A unit slip is prepared for each charge on invoice as journal entry. In this last case the unit slip produced by one company was not a by-product, but contrary to a first impression, it proved to be a considerable saving in time and expense. Unit slips were distributed to the various subsidiary ledger bureaus and the invoice was passed for payment thereby avoiding the hazard of losing a discount. The cost of keeping a record of the whereabouts of the invoice while passing from one bureau to another, the delay caused by one bureau waiting for another to complete the posting, and the elimination of the time consumed in reconciling interim trial balance with control accounts also were avoided.

The Unit Posting Slip Plan

The following is a very simple plan for producing a posting unit from invoices and journal entries in connection with the preparation of an invoice register and posting on accounts payable ledger. The reader may decide which is the by-product.

The unit posting slips are not collated with the in-



voice register and accounts payable ledger for the reason that with 50 per cent of the items a description on the posting unit is desired so that it may be used later as an analysis of current operating expense accounts and as permanent supporting detail of construction charges. The Burroughs Moon-Hopkins bookkeeping machine is used. The posting unit slips come from the printer in continuous rolls and feed through the machine on a split platen. Entry is made on the unit slip (Fig. 2) from an invoice (Fig. 1) of the district or division number, the account number and invoice number. The date is automatic wherever it appears.

In the case of construction charges the name of the vendor, a description of the charge and the amount of charge are entered; in the case of operating expense charges only a description of the charge and the amount is entered, and in all other cases the amount only is entered. One adding register accumulates the total charges for each unit slip, a second adding register accumulates the charges for all unit slips for the same invoice. The invoice number was entered in a fourth register merely to have it repeat automatically by subtotaling. The carriage tabulates to the invoice register (Fig. 3) position and the name of the vendor is typed in, the proper account payable ledger sheet (Fig. 4) is selected and collated with the invoice register, the total keys are depressed causing the invoice numbers to be printed along with the date. The whole procedure is repeated for each invoice. The unit slips then are torn apart and sorted by accounts.

The next procedure is optional. Space will not be devoted to a discussion of the advantages and disadvantages of first distributing charges to secondary accounts and summarizing to produce primary accounts as opposed to "pre-listing" by primary accounts and then distributing to secondary accounts. It is sufficient to say that the company using this plan prefers to use the latter. The unit slips next are entered or "prelisted" by primary or control accounts (Fig. 4) and then passed to the secondary ledgers. The control accounts (Fig. 5) are used as a posting media to the general ledger at the end of the month in addition to serving as a control of subsidiary ledgers.

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*Machine Accounting as Applied to Cost Records**

By G. F. MacKenzie

THE most fertile field for machine bookkeeping in connection with general records lies in cost accounting. This is true because of the large number of entries necessary to cost analysis and there, if at all, indications point toward economy in the application of bookkeeping machines.

Payroll Distribution by Non-Listing Machine Method

A cost accounting system has a decided effect on the manner in which other records are produced. The payroll department, stores department and accounts payable all may have to govern their procedure by the demands of the cost accounting department. A method of payroll distribution used to good advantage by one utility is presented here as it is considered to be rather unusual and has proved to be both workable and economical.

Types of time tickets used are shown in Figs. 1 and 2. The tickets are divided into coupons by means of heavy black lines. Only one charge number may appear on each coupon, the capacity being five charges for the individual ticket and six charges for the crew ticket. Tickets are produced in the field in duplicate, (the form is "carbon ready") the second copy being of light cardboard. The payroll department prices and extends both copies, retains the original for support of the payroll, and forwards the duplicate to the cost accounting department. The duplicates for each day are balanced, of course, with the daily total of the payroll.

A posting reference is obtained by using the first workman's number appearing on the time ticket in the case of crew tickets. If no workman numbers are used, the tickets may be numbered serially by days or months, provided that the same number appears on both the original and duplicate. The reference number is inserted on each coupon. Tickets then are cut up into coupons and assorted by accounts, which provides an easy method of collecting charges to each account daily for the payroll distribution, and obviates the necessity of random posting in the distribution ledger.

The distribution ledger may be posted by hand, by listing machine or by non-listing machine. One utility accumulated three separate items from these payroll

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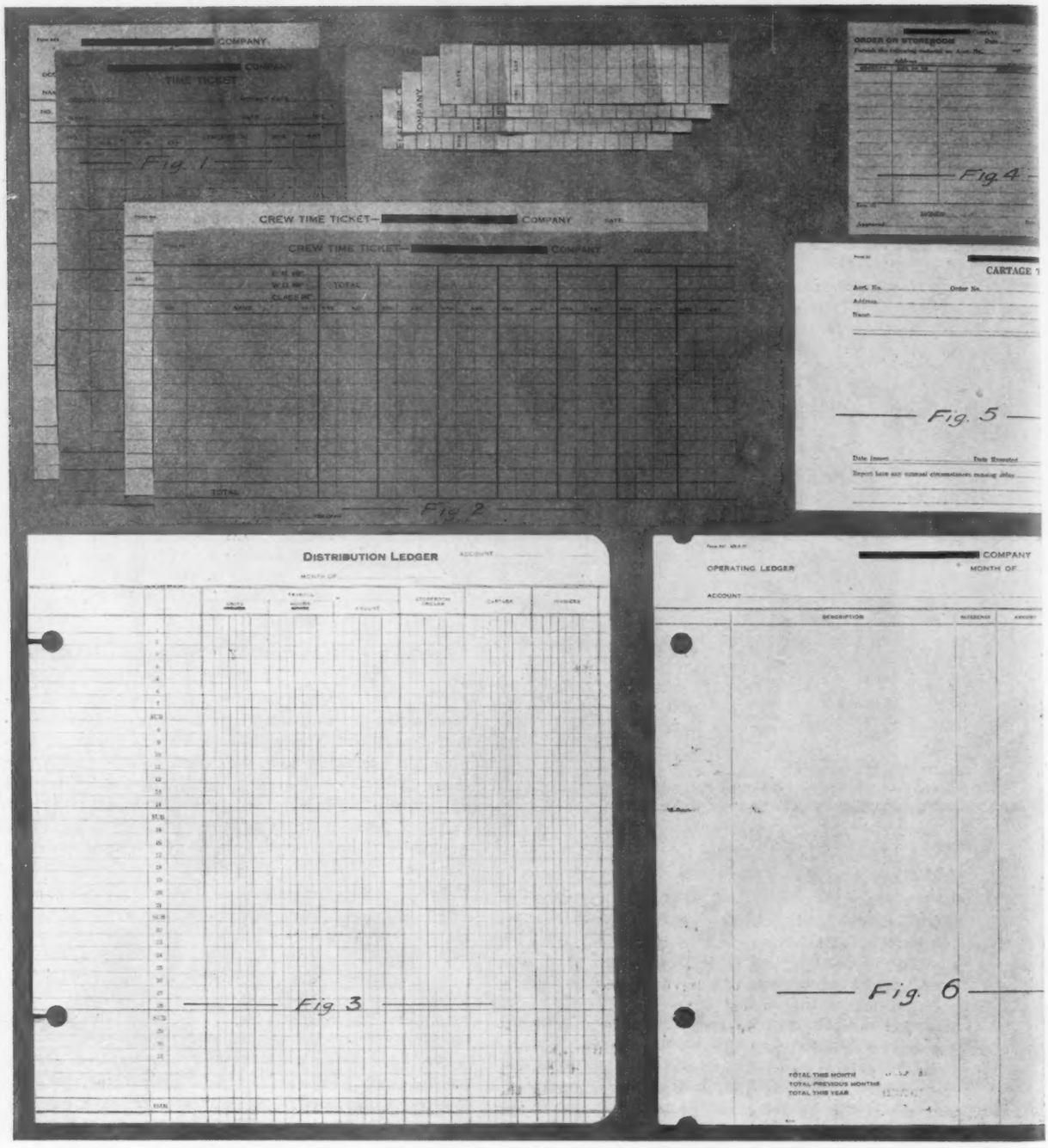
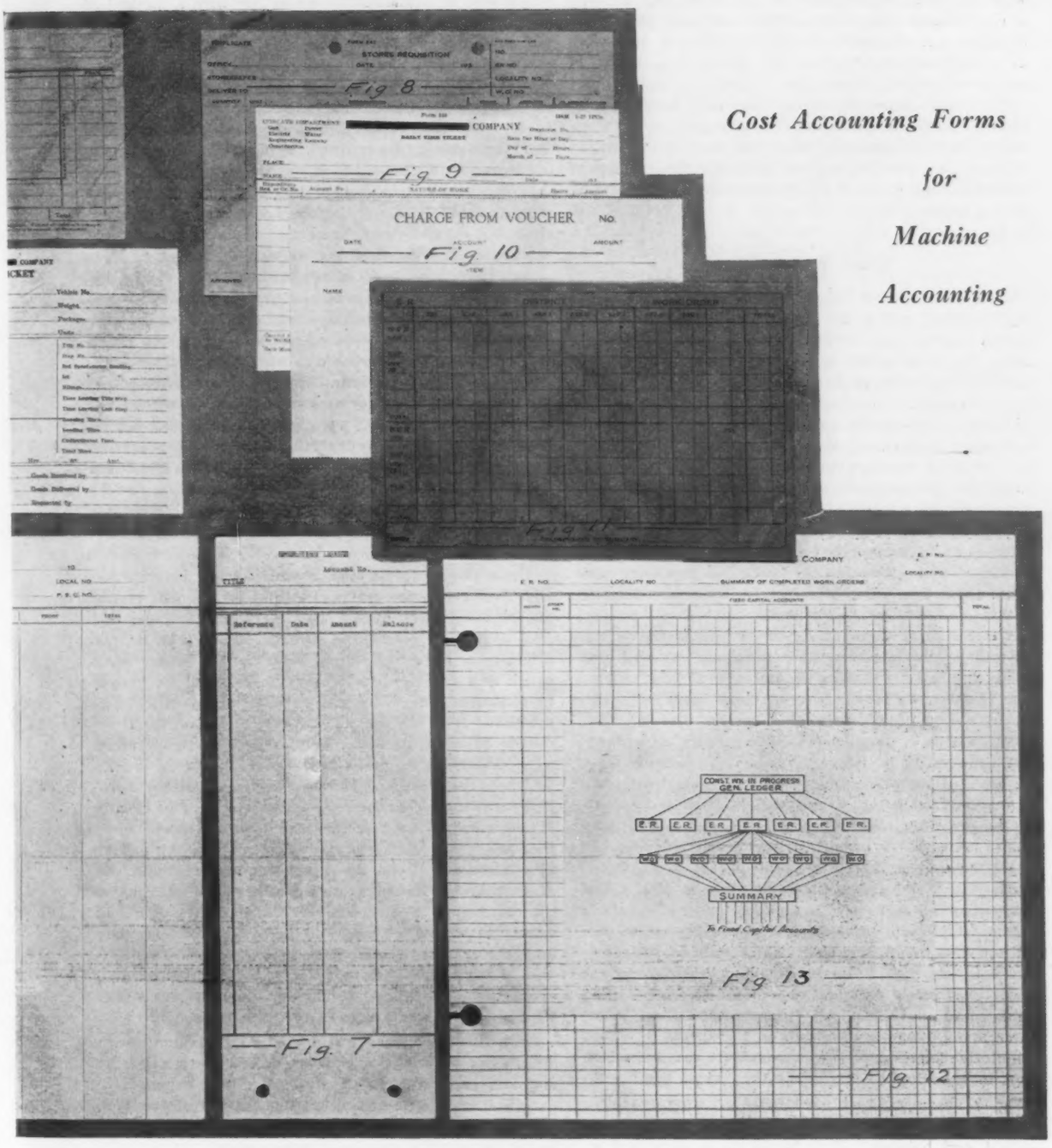
* Supplement No. 2 to the report of the general records committee.



coupons, hours, units, and amounts. Units are a necessary factor in compiling the distribution of payments under a premium system. This distribution is accomplished by non-listing machines (Comptometer and Burrough's Calculator). It does not seem necessary to explain here the advantages of these machines as they are in more or less general use and are the fastest machine for straight addition when used by a trained operator.

The use of the non-listing machine is the most direct method from start to finish, as totals only are entered in distribution ledgers. This means, then, that all the detail of the distribution ledger has been discarded and that some other method of reference must be used in tracing back entries to time tickets. This is accomplished by saving the coupons for a period of two months, after which time it has been discovered that practically no reference is necessary. At any rate, however, charges to any account may be substantiated by reference to the original time tickets. The deciding factor in this installation was that much more time and expense could be saved by using the non-listing machine than ever would be necessary to expend in referring to time tickets and coupons.

It is possible that the claim might be made that, in discarding the distribution ledger, a necessary record has been destroyed. This point may warrant some consideration. The distribution ledger was absolutely



Cost Accounting Forms for Machine Accounting

necessary in the hand-posted methods which have prevailed for so many years and because of this necessity it is quite possible that this record may have come to be regarded in the nature of a book of original entry, which it is not by any manner of means.

Distribution ledgers contain generally only reference numbers and amounts and themselves in no way substantiate propriety of charges to any accounts. Without the original record to refer to, the books are practically valueless. The chief use of these books is to arrive at a total for a certain period of time, and after that total has been obtained the books for the most part are worthless. By nature they are large and occupy valuable storage space where, once placed, they remain undisturbed until someone has enough initiative to burn the paper and salvage the binders. By eliminating the detail in these ledgers, and saving only the totals, an economy is effected in the cost of stationery and the rental of storage space.

There are few accountants today who do not accept totals produced by non-listing machines as readily as those produced by listing machines. The real proof of any total can lie alone in re-addition, for lists have been known to be in error, both from mechanical faults and from deliberate action on the part of bookkeepers.

The machine actually used in the installation referred to is a twenty-bank comptometer which is split into three sections, all three items (hours, units and

amounts) being accumulated at one time. Fig. 3 shows a distribution ledger sheet for use with this plan. Amounts are accumulated daily and entered in the appropriate columns, totaled and balanced monthly by comptometer and the results journalized.

The same principle of sorting and accumulating posting media may be applied to stores requisitions and cartage charges, provided that the requisition and cartage slips can be produced with one charge to each account. Figs. 4 and 5 illustrate posting media of this nature actually in use.

Operating Expenses

Every utility must keep a detailed account of operating expenses which of themselves constitute a cost record as prescribed by regulatory commissions. There are a few utilities which do not require the amplification of these prescribed accounts for obtaining operating information, the burden of the requirements increasing or decreasing according to management policy and other local conditions. In arriving at a satisfactory type of machine installation, all of these local conditions and demands must be considered. It always is a good plan, upon the installation of a new system of any kind, to survey the requirements thoroughly. Often it is discovered that a particular feature of the information produced, which may be expensive and troublesome to obtain, no longer is necessary because of changes in operating methods.

If strict supervision of these accounts is the policy, a detail of charges kept up-to-date continuously may be accomplished by using a machine of the writing type (Remington bookkeeping machine or Elliott Fisher) by means of which written entires may be made to the sheets of the ledger. Occasionally it happens that supervision of labor charges and stores charges are all that may be required and, as this detail may be procured from the distribution ledgers, the operating ledger may contain no written detail and may consist merely of reference numbers and amounts. In the latter case a listing machine of the type of the Burrough's bookkeeping machine may be used. The latter machine also may be used in connection with a system which provides complete detail by use of the posting slip, the principle of which will be fully discussed later. Fig. 6 illustrates an operating account sheet used for a detailed system on the Remington bookkeeping machine. All entries other than labor, stores and cartage are written on the sheets in detail. Cumulative balances of each account are carried, which helps to expedite the closing at the end of the month.

Fig. 7 shows a sheet used with a listing machine, and contains no information other than reference, amount and balance. It is found to be expedient to create a new operating ledger each month so that during the current month the last month's ledger may be used by the various departments without interrupting the current posting.

Posting Slips

An experiment in cost accounting recently has been made by one utility in connection with the use of what might be called the "posting slip," for want of a better name. The underlying principle in this system is the elimination of all unnecessary writing of detailed information. When a record is produced in the field, of which a carbon copy can be made, it may be possible to use this copy to good advantage in cost accounting as a detailed support to a certain entry. The principle will be explained in connection with a method of accounting for small work-orders under an expenditure requisition, although it may be applied with certain variations to many cost accounting ventures.

Time tickets bearing charges to one work order only are produced in the field in duplicate, the original being used for payroll purposes and the duplicate sent to the cost accounting department. The same thing is true of stores requisitions. A control is established for each expenditure requisition of such nature, containing charges made through the voucher register and carrying no detail other than reference numbers and amounts. Posting slips are written up for all charges other than labor and stores, as explained in the description of the application of the Moon Hopkins machine to accounts payable. This means, then, that for every entry to the controlling account, a slip or a group of slips is produced which provides detailed information for the cost records. The slips are balanced, of course, with the entries appearing on the control. The slips then are filed in 5 x 8-in. steel drawer files behind envelopes on which appear the E.R. number, location number and work order number and on which is printed a form for the notation of costs. Figs. 8, 9, 10, and 11 show the form mentioned. The total of all slips appearing in this file must equal the total of the control at all times.

Upon the completion of a work order, information is forwarded to the cost accounting department giving the physical story of the work performed. From this record it may readily be discovered whether or not all charges have come through to the particular work order and the financial story is ready to be closed. In closing a work order, the envelope and posting slips are taken from the file, and slips recapped on the front of the envelope in totals only, the totals transferred to the summary of closed work orders as shown in Fig. 12, the slips placed inside the envelope, and the envelopes transferred to the closed file. The prompt closing of work orders aids in the review of the costs while they are fresh, and keeps the volume of working papers at a minimum. Upon the completion and closing of an expenditure requisition, an analysis of all charges to the requisition is obtained from the summary of closed work orders, and the totals of the closed summary may be transferred to the fixed capital accounts. This system is particularly valuable in connection with small extensions done under a blanket expenditure requisition, an order being written for each extension.

Only direct charges are posted to individual work orders, as only direct charges can be controlled by engineers and superintendents. Overhead expenses to each E.R. are accumulated during the life of the E.R. and apportioned over the various accounts appearing on the summary of completed work orders.

Percentages of overhead costs are established for each E.R. so that the total cost of a work order may be obtained if necessary by adding to the direct cost the percentages of overhead. In accumulating the costs of completed work orders and in balancing to controls, non-listing machines may be used to advantage. This system may be used in the case of a work order which is to be closed to one fixed-capital account only or a work order to be closed to several fixed capital accounts or to the retirement reserve. As the work order detail shows copies of all original entries it is rarely necessary to refer to other documents during the process of analysis as is not always the case when book entries are made for cost accounting. Fig. 13 is a graphic representation of the contact between expenditure requisitions and fixed capital records.

Balancing Cost Accounts

Cost accounts never are of such nature as to be considered as being accounts of original entry. In every instance, they are controlled by accounts in which appear at least the references to entries which later are spread over the cost accounts. A great many cost reports are of value only for a short time after they have been compiled and after a period of, say, one year, might be destroyed without seriously injuring the records of the company. There always is a question, then, as to the amount of time which should be spent in preparing these records.

From time immemorial the accountant has held to the principal of a balance, so much so that many members of other professions have ridiculed his adherence to what they chose to term a "fetish." There are few of us who have not spent an enormous amount of time hunting for a ten-cent mistake in some set of minor accounts which, when found, did not change the aspect of the case one iota. To the accountant, the balance is the one safeguard assuring correctness of entries, but under some conditions, we may find that appreciable ecenomy results from a system which permits in some degree a minor discrepancy to be accounted for in some way other than by hunting through voluminous records for its discovery.

The modern banker has ceased to spend valuable hours of his staff when cash does not balance at the end of the day by a slight amount. (In some cases, the limit for a teller is $5.) After an honest effort on the part of the teller to find the error, he is permitted to charge the amount to cash overs and shorts, and this procedure results in healthier, happier employees with no appreciable loss to the employer. If the banker agrees that this is an economy where an actual cash loss might be involved, it stands to reason that the same principles applied to some accounting venture in which no cash value is involved might also be an economy. Cost accounts by their very nature are voluminous and their compilation demands the handling of large quantities of entries. If it is possible to devise a system capable of handling this large volume at a small expense, but having the possibility of showing an error at the end of a balancing period, the system should not be immediately condemned.

One utility employs a system of this kind which has proven eminently successful over a year's trial. The system deals with the cost accounting of sales orders for appliances and jobbing, and during the year 1929 handled more than 12,000 orders, the total of which amounted to more than $500,000. The posting-slip method is used as already described in connection with expenditure requisition. Copies of labor tickets, copies of store-room orders, and copies of invoices are inserted in the files daily and orders are closed and transferred to the closed summary daily. Accumulation of cost of orders and all balancing is done by Comptometers. The 12,000 orders were controlled through one account and the only attempted balancing was done at the close of each month's business, when the remaining posting media in the open files were added up. In some cases as many as 2,000 orders remained in the open file at the end of the month. The December, 1929, balance showed a difference of $37.03 which was charged off as an addition to overhead expense.

The purpose of this cost system is to provide costs for each sales order and later to provide the total cost for various groups of orders. If each sales order is surveyed before closing, large discrepancies do not occur. Therefore, it is considered to be no violation of any accounting principle to utilize a system of this nature, permitting a very small percentage of error. The original distribution of labor and supplies from the field never can be 100 per cent accurate. Therefore, the percentage of error cited above can affect in no way the operating results obtained from the final cost reports, particularly when it is considered that overhead costs are distributed for the most part on purely hypothetical bases. As closely as can be estimated, a saving of 25 per cent was effected by changing to this system from a method which necessitated the use of ledgers.

It might even be possible to apply this same principle to construction accounting in regard to the case of the expenditure requisition already cited. The E.R. control contains a total of approved charges to the expenditure requisition which can be at all times substantiated. Assuming that 12,000 work orders pass through one E.R. in the course of a year which results in a discrepancy of $37 between the summary of closed work orders and the E.R. control, and that the discrepancy were distributed along with the overhead cost of the E.R., it is believed that the resulting figures to be transferred to fixed capital would be as satisfactory from any standpoint as if the detail had balanced exactly.

Commercial Section Reports[1]

Introductory Statement

By J. F. Orr, Chairman

THE fifth annual mid-winter conference of the Commercial Section was held in Spokane, Feb. 13-14, 1930. At this meeting were heard two committee reports from the power bureau, four reports from the lighting bureau, four reports from the merchandising bureau, and also reports from the rural electrification committee, and promotional rates committee. This meeting was summarized in the March 1, 1930, issue of Electrical West.

Some of these reports have been revised in accordance with the discussions developing at the meeting. They are published in final form in the following pages, and in addition is added a report of the wiring sales committee.

[1] Executive Committee: J. F. Orr, chairman; G. E. Sullivan, vice-chairman; R. M. Bleak, T. W. Fitch, J. D. Scott.

LIGHTING BUREAU[2]

*Sell More Lighting**

By T. W. Fitch

THE electrical industry was developed originally for the purpose of providing a new and better medium of lighting. "Lighting," therefore, was the "first-born" of the electrical industry. As developments came along, however, it soon became apparent that electricity used through motors for power purposes had a more far-reaching immediate field than did electricity used for lighting purposes, and for years the sale of electrical energy as power for operating machinery received the major, in fact almost the entire attention of the industry. Load for lighting was accepted but was not sold.

This condition of "selling" power load and "accepting" lighting load still exists to a large extent in many central stations, largely, I believe, for the reason that many of the executives have received their early training during this period of concentration on power load. Power has been their main interest.

What are the actual facts, however, regarding power load and lighting load and power revenue and lighting revenue?

Thirty-five per cent of the kilowatt-hours sold by the central stations of the country are sold for lighting purposes and 65 per cent of the revenues of the power companies are derived from this lighting load. In other words the 35 per cent of the production which is sold as lighting returns 65 per cent of the total revenues. Lighting rates are higher than power rates.

The possibilities of this lighting field have been but barely scratched on the surface. The growing appreciation of the value of better lighting in industry and of the operating economies possible by the use of illumination of the highest economic level, is charting the way to a stupendous field of revenue at present not being cultivated as it deserves to be.

Good lighting and adequate illumination, however, do not sell themselves and it is only by continuous hammering by well trained men that the old habits of inadequate illumination and the great mass of inertia of thought can be overcome. The old idea that lighting is a necessary evil, and can be taken care of as an afterthought, and that a little light is enough, is now being forced backwards into the dark ages where it belongs and the modern idea of light as a partner in production, as a raw material in industry, cutting costs by reducing the time element and spoilage is coming to the front.

Unfortunately, this same resisting mass of inertia and the old habits and ideas of lighting are present to a measurable degree in our own electrical industry The industry itself is not thoroughly sold on the idea of proper illumination. Witness certain central station properties and buildings over the country. Whether this condition is due to the alleged fact that "a prophet is not without honor except in his own country," or to the other phrase about "shoe-makers' children," is a question. I am inclined to credit the former.

The value of this lighting load on the average is about three times the cost and expense of obtaining it. This fact was brought out clearly in last year's reports. A dividend return on an investment of even 100 per cent is considered quite satisfactory to most people.

Central stations in the various parts of the country which have most successfully operated lighting service departments are constantly enlarging the scope of these departments. They have seen and have proved to themselves that lighting service departments are good investments.

In conclusion—The "first-born" of the industry (lighting), who for so long was neglected and ignored is back again with the rest of the happy family (power, merchandising, etc.) and is doing very handsomely by the old folks who failed to appreciate him in his youth.

[2] T. W. Fitch, Pacific Northwest Public Service Company, chairman. L. V. Ross, The Washington Water Power Company, vice-chairman.

* Report of Lighting Bureau chairman.

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*Commercial and Industrial Lighting**

WHAT have we here in the Northwest accomplished in commercial and industrial lighting along the lines as laid down in our last year's report? It was the opinion of the committee at that time that concerted action should be taken to create a better understanding among the builders of new commercial and industrial buildings, and to stimulate the interest of architects and electrical contractors in better lighting; also, to extend the central station activities in the smaller towns served and to have at least one experienced lighting salesman for each town of 20,000 population.

We realize that it takes some time to get down to real business in any big undertaking, especially when there is a great deal of educational and pioneering work to be done. We believe it is better to go slowly at the start, feeling our way until we have well-defined plans to work on and a goal to work to. We believe we are at that point now and that the officials of our companies do realize the value of the commercial and industrial lighting business more today than ever before.

This has been an exceptional year in the way of stimulating a "light consciousness" in the minds of the public throughout the nation. Light's Golden Jubilee was one of the outstanding factors during the past year. It was instrumental in developing in the minds of the general public the desire for better lighting, not only in our factories and commercial establishments, but in the office and in the home.

Those of us who are directly in contact with lighting phases of the electrical industry are of the common opinion that this change of light consciousness in the past year is quite noticeable in the minds of the electrical users. Where a few years ago the managers of large industrial plants and commercial concerns were somewhat indifferent when approached on the subject of better lighting, today the majority are interested and are willing to listen to our story. It is an opportune time for the electrical industry to capitalize on the propaganda that has been going on the past year.

* Report of commercial and industrial lighting committee. Lynn D. Johnson, Pacific Northwest Public Service Company, chairman.
Pacific Power & Light Company: H. C. McDaniels.
Puget Sound Power & Light Company: H. A. Gardner.
Utah Power & Light Company: George Ellerbach.
The Washington Water Power Company: L. V. Ross.

Co-operation With Architects

The committee's report for last year covered in general the entire field for lighting development in a very thorough manner. There has seemingly been a great deal of activity throughout the various sections along the lines referred to by our committee. The Commercial National Section has recently prepared specification paragraphs for better lighting standards in commercial and industrial buildings. These are recommended to the architectural professions as a model to aid in making plans for electrical installations. The majority of the architects will appreciate this co-operation.

There have been many attempts in the past to co-operate with the architects, but in most cases, for one reason or another, this contact has not been successful. The faults may be summed up in three major reasons: first, the profession as a whole has a reputation of being sufficient unto itself, resenting any effort that in any way might resemble a criticism of practice; second, the opportunities to be found in work of this kind had not been realized; third, the type of service offered the architect frequently has not been to his liking nor has it filled the definite need existing in the majority of such cases.

Lighting service departments of the utility companies should be broad enough in their scope, and equipped with competent men capable of giving the service necessary to fill all requirements of the architects. These departments should be organized not only to check the plans and specifications prepared by the architects relative to the light outlets, wattages, type of fixtures, etc., but also to draw up wiring plans and write a set of specifications complete in every detail as to the size of wire throughout, number of branch circuits for present and future use on the panel board, size of feeders, conduits, switches for entrance service, and distribution cabinets. Where the wiring is left to the contractor, the minimum demanded by the electrical code is generally the result.

This service may be covering a great deal of ground to be furnished by the light and power companies free of charge, but their engineers are the only logical ones to give this service at the present, except in a few of the larger cities where independent consulting engineers are available. We believe we are now on the right track, and a great deal of good is to be accomplished through the proper contacts with the architects.

Report of I.E.S.

To illustrate better the more universal attitude of the architects toward the electrical industry, we quote here from a report compiled by Leroy E. Kern, secretary of the structural service department, American Institute of Architects, given at a recent meeting of the Illuminating Engineering Society. This report is in response to a letter sent out by this organization to the representatives of each structural service department in each of the 60 geographic chapters in the Institute. The opinions of these 60 men may be assumed to be fairly accurate in representing the attitude of the profession at large on this subject.

The letter referred to follows. It plainly shows what efforts are being made by the architects to co-operate with the electrical industry. (Letter taken from January issue of Transactions, I.E.S.)

During the past year the Structural Service Department has had a number of meetings with the Illuminating Engineering Society and with various branches of the illuminating industry in an endeavor to make illuminating engineering service available to the architectural profession.

Strictly professional illuminating engineering service is not generally available today since practically all illuminating engineers are connected with some of the various branches of the electrical industry.

After careful consideration of and consultation with the various elements of the illuminating industry, it appears that the electrical engineers connected with the central stations were in the best position to render a disinterested and authoritative professional service.

"Arrangements are therefore being made whereby a certain number of these engineers in each locality will be given an intensive training in the fundamentals of illumination and of architectural design, and through the central stations the counsel and advice of these engineers will be made available to the architectural profession in connection with problems involving the use of artificial light. As representatives of the Structural Service Departments, we should appreciate your comments and suggestions.

Assuming that they represent a cross-section of the industry, the replies will serve to illustrate what the architects' attitude on this proposition would be.

About 65 per cent endorsed the plan as outlined in the letter.

About 20 per cent were interested and at least were not opposed to the plan.

Ten per cent were opposed or seriously questioned the wisdom of the plan.

Five per cent were interested and are not in a position to express an opinion.

Individual Company Activities

The Pacific Power & Light Company has developed a very close working contact with the architects and builders in its territory. As an aid to this development, the names of the architects and builders have been placed on a mailing list for such magazines as *Light, Revenue, Lighting Fixtures* and *Lighting*. The subscriptions have been paid many times over through the co-operation received. This may be a means of developing a light consciousness in the architectural profession. We believe other utilities could profit by a similar plan. The company has also used the Franklin Specifications and letters to good advantage with gratifying results.

The other sections of the Northwest are continuing their good work in the betterment of lighting in the commercial and industrial field. The Puget Sound Power & Light Company is now launching a very extensive commercial lighting campaign.

In Portland, there are no well-defined plans for co-operating with the architects, although satisfactory contacts have been made with a number of them. The main effort in the industrial field has been the relighting of the old plants, bringing them up to the proper standard. Close touch is maintained with all industrial and larger commercial customers and lighting men are generally called in to assist them in their lighting problems on any alterations or new additions to their plants. Good response to the Franklin letters sent out in connection with other follow-up letters furnished by a manufacturer of lighting equipment has been received.

There was organized in Portland during the past year an Electric Club, which is drawing all branches of the electrical industry together and is developing a closer contact throughout the entire field. Through the club's co-operation with other organizations of the city, Light's Golden Jubilee and the Outdoor Christmas Tree Lighting Campaign, were carried through in a satisfactory manner.

The selecting of lighting fixtures for industrial and commercial use has become quite a problem to store and factory officials. The many manufacturers, with their highly developed luminaries and reflectors, create more of a problem in selecting fixtures than the ordinary

layman cares to undertake by himself, when hundreds of thousands of dollars are involved. The utility's illuminating engineers are often called in to help on such problems. To simplify these matters, there has been developed by F. H. Murphy, chief illuminating engineer of the Pacific Northwest Public Service Company, a grading card whereby each fixture is put through an efficiency test. This card, when completed by the illuminating engineer with the assistance of the officials in charge of the lighting installation under consideration, shows the efficiency of such units. Each factor entering into this test, such as glare, light distribution, illumination efficiency, shadows, maintenance, fixture cost, and appearance is given a percentage rating, according to its value in illumination. On account of the effective work of the illumination department along with the results of these tests, certain schools have changed from direct lighting units to semi-indirect with the result that 11.4 kw., 12.5 kw. and 30.8 kw. have been added to their original lighting loads.

Load and Revenue Data

Some interesting data as to the ratio of light to power have been prepared by H. E. Cook, of Detroit, Mich. Taking 20 different sized industrial plants at random, the ratios run:

	Per Cent
Ratio of power to connected load	68.5
Ratio of light to connected load	31.5
Ratio of power demand to total demand	61.0
Ratio of light demand to total demand	39.0
Ratio of power demand to power connected load	48.7
Ratio of light demand to light connected load	65.8
Ratio of power kw.-hr. to total kw.-hr.	64.3
Ratio of light kw.-hr. to total kw.-hr.	35.7
Ratio of power revenue to total revenue	63.0
Ratio of light revenue to total revenue	37.0

From the foregoing we see that light loads are desirable revenue producers.

Light demands compared to light connected loads produce a higher ratio than power demands compared to power connected loads.

We have much to console us in this question of power vs. light. Power tends to be stable once a plant is completely equipped with electrically operated machinery. Expansion then depends upon the development of new power applications and the natural growth of the plant capacity. Light, as we well know, is still due for a steady increase in application. The end is not yet in sight. Now, where we are applying 8 to 20 foot-candles, in different branches of lighting, Dr. Luckiesh recently predicted that we would soon be talking in hundreds and even thousands of foot-candles.

In comparing two printing plants in Portland, where the connected power load of each happens to be 67.5 kw. with a power demand of 40 and 37.5 kw., respectively, the connected light load of the first is 32.5 kw. with a 15 kw. light demand, and of the other is 6.8 kw. with a demand of 4.0 kw. The first has a yearly power revenue of $1,240, and a lighting revenue of $816, while the other has a power revenue of $701 and a lighting revenue of $329. What we want to bring out here is the comparison of lighting revenue of $816 against $329. The first was relighted about two years ago, the other is now being changed.

Another case, the Columbia Knitting Mills, where the light and power connected load are now practically the same, or 22.5 kw., the lighting revenue is $887 annually and the power is $600.

New Division of Committees Suggested

Now that the Lighting Bureau is beginning to demonstrate that it is a valuable asset to utility companies and is destined to become one of the most important departments of the Commercial Section, special effort should be exerted for the proper development of these activities.

As the home lighting and advertising committees have their own committee heads so should the commercial and industrial committees be separated. This would have a broadening effect with the result that more definite plans upon which to proceed can be considered. The general activities of these different departments are of course similar, but definite workable plans for the one may not be at all practicable for the other. The industrial lighting activities call for a greater difference in their set-up than do the activities in these other departments; therefore, an industrial committee head is imperative for the best results.

Any particular plan of activity to reach the desired results may not be so important, but there should be a set goal and well defined plans on which to work.

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*Street and Highway Lighting**

THE purpose of this report is to summarize the three previous reports and to suggest a definite form of procedure to accomplish the objective of the three previous reports. This objective is increased thoroughfare lighting and resultant contracts to supply electrical energy, but further, when we are working for increased illumination and better street lighting systems, we are working hand in glove with forces of progress. We should throw off the old restraining force of political fear and go out in a convincing and decisive manner to get more street illumination. We should no longer be held back in our activity by the crippling thought that the public will think that all we want to do is to increase our revenue. For that, of course, power companies are in business. That is what is being done every time an appliance sale is made, but we know that every time we equip a home with electric appliances we are not only adding to our revenue, but we are making life more livable in that home. For every dollar of revenue obtained we are adding to that home, and we must know, and be certain that every time we increase street illumination we are giving value for every dollar expended for it.

Last Three Reports Summarized

Every power company man should be a working agent to promote safety and convenience to the users of street and highways, to enhance the value and increase the attractiveness of the streets and cities by providing sufficient light to give adequate visibility.

The first and second reports of this committee were concerned with:

1. Desirability of the street lighting load.
2. Its development and financial aspects.

The third report dealt with general recommendations for securing the street lighting load. It made general classifications by designating:

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* Report of the street and highway lighting committee. G. L. Corey, Pacific Power & Light Company, chairman.
General Electric Company: G. N. Barker.
Idaho Power Company: J. W. Crow.
Westinghouse Electric & Manufacturing Company: G. N. Boyd.

1. The customer or purchaser.
2. The article offered.
3. The salesman.
4. Financing. Under financing the committee attempted to define the selling expense or cost of developing and securing the business.
5. Sales plan.

In these three preceding reports we have the essentials of a foundation on which may be erected the sales structure or organization for actually producing the lighting contracts. The contract is the culmination of the suggested effort and plans in the three preceding reports. It now remains only to formulate a definite working plan and to form a practical functioning organization through which the central station company may actually realize its ultimate object. The thing we must do now is actually connect to our power lines actual street and highway lighting systems. The question is, how may this be done?

In the third and last report of the group was outlined a sales plan which, though somewhat indefinite, is still a plan. The general conclusions drawn were:

1. That the idea to be sold is the benefit of street lighting.
2. That the central station should sell itself the idea and then organize for an effective merchandising of street lighting benefits.
3. That the commodity itself must be sold to the property owner who is the ultimate customer.

We must then realize that street lighting is a saleable commodity, that public interest requires street illumination of greater intensity than present standards, and that the central stations must organize for effective merchandising of street lighting by making the commercial department responsible, by building up a lighting service division, by selling the advantages of the street lighting load and by thoroughly surveying the possibilities for street lighting development. These are still generalities and most of them are truisms. This committee has asked itself this question:

"If I were the sales manager of a central station company, just how would I apply the general ideas and principles set down in the three previous reports? Just what must I do in order to get contracts for furnishing energy to be used in lighting the streets in my city or the highways in my state?" This of course is a question which can only be answered in detail by each individual who is responsible for merchandising the energy generated by the company which he represents. It is obvious, however, that a concrete plan of action which might be suitable for a large central station organization operating in the larger cities might not be applicable to a smaller city organization. We, therefore suggest different plans for these two different classes. A suggested form of organization is as follows.

Large Central Station Companies

There is literally no essential difference between the merchandising of an intangible commodity like electrical energy and transportation service and the merchandising of concrete and material objects which may be seen and touched. The latter are merchandised by the commercial sales departments of central station companies very successfully, and rather elaborate organizations are formed to handle the distribution. It is logical to conclude, that similar methods would be equally successful in selling the intangible commodities. Therefore, the first step is to place the responsibility for the selling of street lighting definitely on the commercial department.

It is also obvious that, following the same line of procedure in the merchandising of other commodities, some one in the commercial department must be responsible for the sale of the commodity which is being handled. Current consuming devices are sold usually under the direction of a merchandise sales manager. Therefore, there could be appointed a street and highway lighting sales manager, an individual who is or may become familiar with standard illumination practice. He might well work with the illuminating engineer, employed by most large central station companies at the present time.

The street lighting sales manager should be charged with the responsibility, first of familiarizing himself and assistants with general street lighting plans and principles of design. These need not be of a highly technical nature, but there should always be available a technical advisor, perhaps the central station company's illuminating engineer.

The duties of the street lighting sales manager should be to survey the territory under his direction for potential street lighting business and follow all rumors of interest in any particular community in improved lighting; to develop by various means an interest in improved lighting where such an interest does not exist; to assist improvement associations and community clubs in the preparation and circulation of petitions to the city council where desirable or necessary; to assist in the organization of improvement associations and keep in touch with such associations after they are formed; to enlist the interest of the companies' legal departments in charter amendments where city charters do not permit street lighting as public improvement, and to work with city engineers, assisting them in the preparation of plans and specifications. He should be an individual of sufficient resourcefulness and with a sufficient degree of independence of thought to be able to develop the potential street lighting business in exactly the same manner as the head of a particular department in a department store or the proprietor of a specialty business, develops his field. We believe that such a department should be designated as the street and highway lighting department, for the reason that potentialities of highway lighting over-shadow street lighting as will be pointed out later.

Small Central Stations and District Offices of Holding Company

The same general plan as outlined for large central stations may be applied in modified form in district offices of holding companies and small central stations. The responsibility, however, should be placed with the district or field representative rather than to appoint a street and highway lighting sales manager. The district or field representative is usually a person of enough importance in his community that his opinion is sought on illumination problems. He should, therefore, follow the same general outline of procedure recommended above for the street and highway lighting sales manager in the larger central station organizations.

We have referred above to a specialist in the street and highway lighting sales department to handle highway and public area floodlighting. In further explanation of this point we would like to point out the intimate relation between public area floodlighting and highway lighting. We believe that floodlighting as applied to the lighting of public areas such as parks, amusement grounds, public memorials and similar applications is a part of the general street and highway lighting scheme, rather than a part of the general outdoor and advertising floodlighting scheme, and we

recommend that such public area lighting be included as a part of the activities of the street and highway lighting division of the commercial sales department of central stations.

It is recommended that a complete survey be made by the street and highway lighting department to determine where increased lighting is required and where old systems may be rehabilitated to provide improvement in illumination, and where lighting may be used to advantage, but is not at present installed. This survey may be used as a guide to the sales activities of the department.

Suggested Street Lighting Manual

City councils and citizens unconsciously look to the power company man for advice and leadership in all things electrical. He should be a leader in the better application of things electrical, and too often he is not able to give intelligent advice on matters pertaining to street lighting. To enable him to give this advice and to promote his leadership in the community, a brief elementary manual of street and public area lighting will be furnished covering the following ideas:

(*a*) Whether the system should be multiple or series.

(*b*) The necessary pieces of equipment to go into a street lighting system.

(*c*) The approximate height of the standards, or lighting units for the different applications.

(*d*) The approximate spacings and arrangement of standards.

(*e*) The size of lamps.

(*f*) Type of refractor distribution to be used, if any.

Enough information should be in this elementary manual to enable the local power company man to enter intelligently into the discussion with customers, helping to formulate basic ideas for the large number of cases as to what form of good street lighting would meet the needs of the towns his company serves.

The District Should Be Zoned.—The towns and cities should be classified by population, market importance and their position on the tourist thoroughfares.

Population.—It is evident that towns and cities will differ in their needs as to lighting by the number of their inhabitants.

Market importance.—The number of people which could be induced to come into the city in the evenings, for show window shopping, for amusement or to bring their produce in for sale, will materially affect the highway lighting to the city and the lighting of certain streets within the city.

Cities Should Be Zoned.—Streets should be classified according to their use and importance and the impression which could be made. Streets with the greatest amount of use should have the largest amount of illumination. Streets which are used most should have the form of lighting which is more or less ornamental.

Every time a power company man takes a look at the cities served by his company, he should ask himself these questions:

(*a*) Has this city a sufficient general illumination?

(*b*) What streets should have some form of whiteway or ornamental lighting?

(*c*) Has the principal street used by the passer-through, a form and quantity of lighting which would leave a good impression as to progress and activity?

Costs—Probably the first question which would be asked a power company man by those approached or interested in more lighting is, "What will it cost?" The principal element entering into this is the rate.

Rate Study Urged

A survey of the street lighting rates in this territory reveals that they differ so materially that it seems important enough for us to suggest that the power companies would do well to enter into a fresh study of street lighting rates. It has been found that the city authorities are gathering data over the entire territory, making comparison with their local rates and in same cases it is resulting to the disadvantage of the local power company in loss of business and is encouraging the municipal ownership idea.

This study, we dare to suggest, should be undertaken with the following guiding principles:

(*a*) The actual capital invested in material which is used for street lighting purposes only.

(*b*) The capital invested in generating equipment which in most cases would have to be invested whether there were street lights or not. This property should not be weighed in too heavily.

(*c*) The added business a power company enjoys each time more light is installed on the streets in the form of increased commercial lighting and the bringing of new residents into the city.

(*d*) The advertising value. We spend much money advertising our business. We urge our customers to do so. The power company's place of business is the city and cannot we rightly charge to our advertising budget a certain amount of rate charge on street lighting, if by so increasing street lighting we advertise more pointedly our place of business, the city?

(*e*) Discouragement of part time circuits by adjusting rates so that all-night burning of street lights will be more advantageous.

The organization manual of the National Electric Light Association recommends that the activities of the street and highway lighting committee of this association should be to survey street lighting practices, both equipment installation and selling methods, as a guide to utilities in promoting this class of business; to study highway lighting and develop plans for advancing street lighting in rural fields; to develop flood lighting practices as an adjunct to street lighting and to encourage in every way the better illumination of public areas This recommendation from the parent association gives point to and emphasizes the recommendations in this report.

Airport Lighting

An elementary manual should also be prepared, following the suggestion of the U. S. government, as to what pieces of equipment should be employed in lighting certain types of landing fields. This manual should contain again enough data to enable one to figure out the approximate connected kilowatt load.

Lighting for Athletic Purposes

Stadiums, Tennis Courts, Baseball Fields, Golf Driving Practice Fairways, Race Courses—The demand of the public to participate in or view different forms of athletics and their inability to take business hours for these purposes is again bringing to our attention the fact that the day may advantageously extend into the night.

Outdoor Floodlighting

(*a*) For commercial purposes where work is being done.

(*b*) For advertising purposes on buildings.

(*c*) For aesthetic and educational purposes, monuments and public buildings. Color lighting, both mobile and static.

Highway Lighting

Last year's report recommended:

(*a*) That a campaign be launched to develop highway lighting.

(*b*) That a bill be prepared and introduced, authorizing state and county boards to plan, install and operate lighting systems for the public benefit on public highways and to provide funds for same.

This committee wishes to emphasize these recommendations and to make its own recommendation that this association immediately appoint a committee to carry out the recommendations in last year's report as noted above, and that such a committee be instructed to lay out a definite campaign and to prepare a bill or bills to conform to the legal requirements in each state covered by this association to be presented to legislative bodies of the respective states, authorizing the planning, installation, maintaining and operating of highway lighting systems and providing funds therefore. Such legislation has been proposed and bill presented in New York, New Jersey, Ohio, Georgia and Illinois and possibly in some other states of which we have no record. The state of Illinois, however, is the only state which has actually passed a law of this nature.

Such legislation is of the utmost importance as it will not only open an entirely new field for the central station companies, but will have a very decided effect on rural electrification, the two being very intimately related and one depending largely on the other. The value and in fact the necessity for such legislation may be visualized when we realize that up to the present time efficient lighting has been installed on only 600 or 700 miles out of approximately four million miles of highway. Such a small fraction is difficult to visualize. The lag in the development of this source of revenue and the extension of this public benefit is due to lack of funds for installation and maintenance of highway lighting systems and lack of machinery for providing such funds.

A substantial and consistent development of this field can only be made by use of public funds. Here is a public function which deserves close attention. If ever a universally distributed tax were justified, it is here. Not mere convenience, but traffic control and safety are involved, touching the interests of every man, woman and child in every community. Efficient illumination will practically double the motor mile capacity of the highways. This committee believes that this association should in no uncertain terms commit itself to a definite program of promotional activity in the interests of illuminated highways.

We believe that the best and most immediate results may be secured in the appointment of the committee hereinbefore referred to.

There are installed in our territory many hundreds of miles of pole lines, on which the added revenue of a 250-watt load every 300 or 400 ft. would be a very satisfactory addition. Moreover, there are many sections into which lines could be built at little cost to the domestic consumer if a load in the form of a highway lighting load could be secured.

The Detroit Edison Company has built up a highway lighting load along 400 miles of its rural lines. In a letter recently received the company states that it will build a rural line for $1,000 per mile less a credit of $100 for every customer. However, if the township will install a highway lighting unit (and the company seeks to get this unit equipped with a 600 candle-power lamp if possible, but will accept a smaller lamp), every 300 to 350 ft., it will install this line entirely at the company's expense. This amounts to 15 to 17 lamps per mile for which, in the 600 candle-power size, the revenue is $48 per year.

The Detroit Edison Company's observation has been that when the rural customer realizes he can get his line built free in this manner he brings influence to bear upon the township's board to enter into an agreement to secure these highway units.

It seems to us that if we had some kind of legislation which would enable the state legally to set aside money for the maintenance of highway lighting units, or would enable rural communities to form rural improvement districts, or would enable cities to set aside money to maintain said lamps along important highways, or farm-to-market roads, a double service would be rendered—the lighting of the highways for convenience purposes and the enabling of rural sections to have electric service at no investment cost to the customer in some cases and at a reduced cost in other cases. It would appear to us that with the increased interest in the farm-to-market road idea and with the desire on the part of many cities to increase marketing and trading in their centers, they would lend themselves readily to a means by which such purposes would be accomplished. How attractive the two could be made if the roads were so lighted that farmers might get their produce to the cities by means of comfortably lighted roadways—and how much more willing they would be to go into the cities at night for their amusement. It should also be remembered by the merchants that tonight's window shopper is a potential purchaser for tomorrow.

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*Electrical Advertising**

IT SEEMS that the task assigned the advertising committee is: "To compile data of informative nature with respect to the use of electricity for advertising, to note the field available, and from a study of these findings formulate plans that could be used to secure this business."

Electrical advertising needs no introduction to those associated with this territory, but it certainly must be introduced to the average business man by an extensive educational program that will convince him conclusively that it is a profitable advertising medium. The importance of our job is not so much to sell our customers a sign, window lighting unit, or flood lighting unit, as it is to sell him on the value to his business of this electrical service.

The Society for Electrical Development recently issued a pamphlet called "A Plan to Sell Electrical Advertising." Even a hurried glance through this booklet convinces one that it is highly desirable for the utility and sign manufacturer to develop this advertising load. A closer observation of it reveals many almost startling, as well as interesting possibilities.

Among things of interest we find that the potential annual gross revenue of this load is equal to the population of your town multiplied by $1.50; that it costs but 7½ cents for every $1.00 of gross revenue to develop this business, and that this revenue is accumulative; and that the reason the power companies have

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* Report of the electrical advertising committee. H. C. McDaniels, Pacific Power & Light Company, chairman.
Electrical Products Corporation: Bruce McGregor.
Northwestern Electric Company: Fred Zaugg.
Puget Sound Power & Light Company: W. A. Gardner.
The Washington Water Power Company: L. V. Ross.

made no effort to take this 120 million dollar advertising market off their laps is because they have been experiencing growing pains and it has taken all of their concentrated efforts to develop a financial structure and to maintain plant and equiment so existing business could be served properly. We have now reached a point, however, where natural growth no longer satisfies; it is time to sell.

The Electric Sign

Formerly the electric sign was a by-product of most sign painters and certainly not, in most cases, a thing of beauty in itself. The use of the Neon gas tube for the electric sign has brought about a very marked change in the trend of sign manufacturing. The Neon tube has not, as many thought it would, spelled death to the incandescent sign. Quite the contrary is true. Just as household mechanical refrigeration has increased the sale of artificial ice, so has Neon increased the sale of incandescent lamps and signs. Many who feel their business justifies a sign, yet not to the extent that they are able to buy the Neon signs, have one made for them using incandescent lamps. Also, in a large percentage of Neon signs it has been found necessary to employ a combination of the two types of lighting to bring out the individuality of the advertiser, and beautify the design. When a combination is necessitated, higher wattage lamps are essential to compete with the brilliancy of the Neon tubing and again the lamp manufacturer and utility realize a greater revenue.

The increasing necessity and demand for the combination type of sign is doing much to relieve the poor power factor situation of the straight Neon sign that utilities at first feared. Another factor that offsets the poor power factor condition is the continuous burning period that is recommended for the Neon sign. Though the Neon sign may have a power factor of less than 50 per cent it is certainly more than compensated for by the 24 hour burning period. Also, when taken into consideration with the balance of the incandescent lamp load of the business establishment it advertises, it should offer no alarming problem with respect to system load factor.

Advertising Value of the Illuminated Sign

Sign advertising is of the greatest potential value as it definitely establishes itself and its location as a land mark. Originality of design is one thing most cherished by the advertiser. The examples of where certain trade marks or copies have been adopted by the advertiser, and the enormous values they placed in these, is commonly known. This is shown especially by the eagerness of most advertisers to provide the best mediums possible in displaying them.

Revenue Value of the Sign Lighting Load

Inasmuch as the sign load burns more on the off-peak period than otherwise it is an especially desirable load. Its load factor is high and the long burning hours make the sign the highest revenue producer per kw. of demand of any load on our lines. To keep this revenue at a maximum, maintenance service is highly desirable and figures from the four corners of these United States can be obtained to prove the justification of such a service. Most utilities have maintenance clauses in their tariffs and are finding them highly profitable, not from the maintenance standpoint, but from revenues that accrue from the filled sockets.

Neon signs are usually maintained by the manufacturer. Because of their brilliancy, and the fact that perhaps the entire sign will go out at once, little revenue loss is experienced due to outage. The customer notices at once when his sign is not burning and makes haste to report it, as he realizes he is suffering an advertising loss all the time the sign is not burning.

Potential Market

There are some 16,000 signs in the State of Oregon using Neon lighting in some manner. Even if this figure were multiplied by 10 the saturation point is far from being reached. In Seattle, there are approximately 15,000 signs in use at the present time of which 60 per cent are Neon alone, and the remaining 40 per cent combination Neon and Mazda. This figure of 15,000 represents a saturation of the sign market of 11 per cent. The degree of saturation will vary in different localities. In some cities we find a well organized manufacturer going out after the business in a manner creditable to any enterprise, while in other cities the sign selling activity will be at its lowest ebb. To say that a saturation point will be reached within a certain time is almost without reason. Great changes have taken place in the business world in the past few years and with competition becoming keener as each day passes, the necessity of advertising is becoming more and more elaborate, so the sign purchaser of today is a prospect for another sign a few years hence. When viewed in this light, it is doubtful if the field will ever become saturated to the extent that sign manufacturing will cease to operate.

This year will be one of the highest years in the history of sign manufacturing and selling. Much research effort will be devoted to perfecting new colors in Neon and in making traveling or flashing Neon a real success. Sheet metal work will continue to improve along artistic lines and many beautiful and outstanding signs will result.

Developing a Selling Plan

As many different plans are available as there are utilities, and these are all on record. The sign business is highly specialized, and unless the utility can afford to have a sign specialist, they cannot be of any outstanding value to the manufacturer in the selling of signs.

Perhaps the best we can do in the Northwest when a customer mentions electrical advertising is to tell him something of the advertising value of the sign and then turn his name over to the sign manufacturer as a prospect. By co-operating in this manner we can do the sign manufacturer a lot of good as well as the utility we represent.

For a more detailed selling plan, we recommend the booklet mentioned in the opening of this report.

Illuminated Poster Panels and Painted Bulletins

There is much property conspicuously located, whose general appearance would be improved by a neatly constructed and illuminated poster board or painted bulletin. Neon lighting has found another adaptation in bringing out very effectively the condensed message of the floodlighted bulletin. With the advent of the newer mobile type of sign, the painted bulletin is destined to experience a great growth in the future as the companies selling this service have men well trained in advertising and they capitalize on every possible development. One has only to look to the past growth and development of this load to get an idea of what it will mean to the utility in the future.

Window Lighting

Window lighting has been given much consideration in the past few years, especially by the lamp manufacturers, and the manufacturers of this type of equipment. There is available as a result ample material on the subject, and figures prove conclusively its value as a medium of advertising.

The principles of good window lighting practice are well known to all. No longer is the bare lamp considered effective and good practice. It has long since been displaced by the scientifically designed reflector, mounted in the upper front corner of the display window with the outlets spaced so an even distribution of light will be directed to the display area. Modern tendency has been toward the use of colors, fixed and mobile, the latter meeting with great favor and success as it possesses the "IT" so essential in window lighting. Some extremes are noticed where only spotlights are used. This produces a spectacular effect but it does not display the merchandise to its greatest advantage.

People may be stopped by such a lighted window, but they never linger as they cannot examine the merchandise on display and seldom return to make a purchase. Plenty of light is necessary to display merchandise advantageously and the better class of dindow decorators work their novel effects from supplementing spotlights. Modernism has recently found its place in window trimming and many unique and pleasing effects that produce stopping power are contrived.

Daylight Reflectors

Daylight reflectors still present a problem. Various methods to overcome this effect have been experimented with, but as yet no really successful solution to the problem has been found. Larger wattage lamps have been used but the resulting heat, due to insufficient ventilation, has been more damaging to the merchandise on display than the success of eliminating reflections. High wattage, focusing type spot lights have been used with a fair degree of success. The beam is projected on a particular article in the window in an effort to make it stand out.

In Electrical West of March 1, 1930, a very practical solution to the problem of daylight reflections suggested the use of the waste space found above practically all store windows for higher mounting of units, more ventilation and better daylighted windows. The "Art Moderne" architecture motif can be admirably adapted to such a store front. It remains for us to transmit this idea to architects and building owners if we are to be of real service to them.

Revenue Value of the Lighting Load

The desirability to the utility of this load is certainly equal to that of the sign load, and as a revenue producer it is perhaps equal to the sign load per kilowatt of demand. With the noticeable increase of daytime burning of the window lights in an effort to reduce daytime reflections, its value as a revenue producer is constantly increasing per kilowatt installed. Intensities as well are on the upward trend and this again greatly increases the desirability of the load.

Developing a Selling Plan

The best plan to increase wattage in window lighting is just good, hard, common sense selling. The contractor-dealer must receive your co-operation and equally important, the architect. Here the ground work for future load increases is accomplished and all of us know the cost of inadequate wiring. Proper contacts made today with the architect pay dividends now and increased dividends in the future. Help him with his wiring specifications and in doing so endeavor to get in capacity in copper that will provide for at least 200 watts per lineal foot of plate glass, and more if you can.

Your help in locating the outlets will also be appreciated and may result in one more outlet in the window than the architect had originally planned. If you can sell the economical value of this practice to the architect, as well as the value to him for future business, it is usually a rather simple matter for him in turn to sell it to the prospective customer, as he is entirely dependent upon the architect's knowledge of building construction and usually accepts without much argument any recommendations the architect makes. If properly approached, architects welcome this type of engineering service as they usually admit their knowledge on this subject is limited, and they especially appreciate this service because it comes from an impartial and disinterested source.

The cost of securing this class of lighting load is not excessive and will vary in different communities. It is perhaps not as reasonable to secure as the sign load, but nevertheless all efforts expended in this direction are bound to pay handsome returns.

Floodlighting and Spectacular Lighting

Light's Golden Jubilee, the Barcelona Exposition, and more recently, the so-called Colorama lighting in the dining room of the St. George Hotel, have perhaps brought to the attention of the American public more than all our other efforts combined what can be done in this line of lighting, together with its potential advertising value. Nationwide, even worldwide publicity, through every possible channel, was given these outstanding events, and through some of these channels the public read about it, heard about it, or saw it.

Nearly every community has a building of note, statue of renown, or some prominent park that is ideal for a floodlighting installation. When floodlighted, these become landmarks of the community as well as advertising material for transients.

Fixed and mobile colors in floodlighting produce effects beyond realism. The architectural beauty of buildings is sometimes greatly enhanced under the colored beams of a floodlight projector. Nature's beauty is even made more exquisite at night than by day.

Advertising Value of Floodlighting

The value of this class of lighting in the Northwest as an advertising medium is equal to that of the sign or window lighting, due to the fact that not many installations are to be found, and because of the few in number, the impressions made will be remembered long afterward.

As a producer of gross revenue it is a highly desirable load and should for this reason receive your co-operative efforts. However, the cost to secure this class of lighting is extremely high when compared to that of securing sign and window lighting load. This is perhaps due to the fact that it is more or less new to the general public and they classify it as a luxury as far as their business is concerned. It remains for us to sell them on the idea of its value as an advertising medium, and great advances in the art of floodlighting itself, as well as its advertising value to the customer can be expected in the next few years.

The chairman wishes to thank the committee members for their co-operation as this has aided materially in assembling this report. Although no figures have been presented, it is hoped that the value of the report is not lost. We urge that this work be carried on in the future and hope that through the succeeding years results will continue to accrue.

*Home Lighting Education**

THE scope of the home lighting educational committee is defined as follows:

"To obtain facts and disseminate information on lighting methods in the home; to develop programs to build the home lighting load; to advance better lighting methods and better lighting equipment; to encourage special lighting service to customers; and to promote in every way possible the use of electric lighting in the home in a beneficial way to the consumer of electricity."

Surveys and statistics of the country as a whole indicate that lighting equipment in the home is far from the point of saturation, and that the home field offers wide possibilities for additional load.

Of the customers on record as of Dec. 31, 1928, about 82 per cent were domestic lighting customers, and the revenue from these residential customers accounts for approximately 29 per cent of the total revenues of the central stations.

Analysis of Domestic Revenues

An analysis conducted by the National Electric Light Association covering the two-year period, 1926-28, showed an increase in domestic customers of 15.1 per cent, an increase in kw.-hr. sales of 33.8 per cent, but an increase in sales per domestic customer of only 13.6 per cent.

The big problem indicated is to increase the energy use per customer. There are 19,000,000 homes in the country which are prospects for improved home lighting, of which about 400,000 are in our own Northwestern territory.

The average figure for kw.-hr. use per year per residential customer is 507; on the Pacific Coast, however, we are going above this figure with an average of 1,008. This high average, however, can be accounted for by the wide use of electric ranges and electric heating equipment, and the proportion of this 1,008 kw.-hr. actually used for residential lighting, more than likely is fairly close to the figure for the country as a whole. Taking a figure of $22 per customer per year for residential lighting multiplied by the 400,000 approximate number of customers, indicates that from our residential lighting we are receiving a yearly revenue of $9,200,000.

This present revenue received is from energy used in homes inadequately lighted. The National Home-Lighting Contest of 1924 proved that the average home of the country was only 50 per cent adequately lighted. If the homes of the Northwest were brought up to a "conservative ideal" the energy consumption could be raised at least 25 per cent by the increased use of home lighting alone. Twenty-five per cent of $9,200,000 is $2,300,000. A 25 per cent increase in the use of electricity for lighting in the homes of this territory would be equivalent to the revenue from 25 per cent greater territory at no further capital expense.

Table I is very interesting and illuminating in that it brings the level of the aforementioned "conservative ideal" to a comparison with the level of lighting conditions found in the average wired home.

TABLE I

	Average Wired Home	"Conservative Ideal" Home	Per Cent Saturation
Convenience outlets	3.4	10.5	33
Ceiling fixtures (satisfactory)	6.1	11.5	53
Wall Brackets (utilitarian)	2.5	8.0	31
Portable lamps	2.8	8.5	33
Connected load in watts	(954)	(1,845)	(51)

This "conservative ideal" provides for the various rooms of the house as follows:

	Watts
Living room—3 convenience outlets; 1 ceiling fixture; 6 portable lamps (including portables in sunroom, reception hall, dining room and various other places not otherwise listed)	540
Dining room—1 convenience outlet; 1 ceiling fixture (1 or 2 small portables possibly)	230
Kitchen—1 convenience outlet; 1 ceiling fixture; 1 wall bracket	200
Bedrooms—Average 2.5 bedrooms per home. 2.5 convenience outlets; 2.5 ceiling fixtures; 5 wall brackets; 2.5 portable lamps	475
Bathroom—1 convenience outlet; 2 wall brackets	100
Hallway—1 convenience outlet; 1 ceiling fixture	50
Basement—1 convenience outlet; 5 fixture outlets	250

Aesthetic Factors

In addition to the revenue which can be obtained in this field, electric service companies should not lose sight of the tremendous influence they can exert toward the conservation of eyesight and the betterment of living conditions by promoting good home lighting.

I wonder how many of the homes of those reading this report would come up to the standard of this "conservative ideal" home. If any of our homes do fall short, it would be a revelation to us to experience the amazing change which comes over the entire atmosphere of the home when our home lighting is brought up to the standards of present possibilities.

Reading lamps shedding a soft white light on our books, but not into our eyes; lamp shades giving warm color tints to the room as you enter or as you gaze about; throughout the entire room, the soft fluorescence from one of the new totally indirect floor lamps reflecting light from the brightened ceiling with all harsh contrasts of bright spots and dark spots eliminated; perhaps a glow of subdued color from a small light ornament on the radio or bookcase or buffet; a picture lighted with a picture lighting unit, so that the high lights are brought out as the artist had intended they should be—these are effects readily produced in modern practice. The salutary effect upon the disposition of the family and congeniality of our friends would be more than ample to repay us for our trouble, if we consider it trouble.

Comparing this "conservatively ideally" lighted home with the average home as lighted today, we obtain a factor which applied to the residential customer load we have at present, will chart possible growth.

Contact Domestic Field Through Women Employees

Each company represented here has a large number of women employees, many now in homes of their own, and many more who will be establishing homes of their own in the near future. It appears to the committee that here is an excellent point of contact with the domestic customer field.

If the homes of our own employees reflected the best or even the "conservative ideal" in residential lighting, the movement toward a general revision upwards would receive a wonderful impetus. The social contacts of central station employees are very far reaching. The urge toward better living surroundings has received

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* Report of the home lighting educational committee. T. W. Fitch, Pacific Northwest Public Service Company, chairman.
National Lamp Works: Walter Potter.
Pacific Northwest Public Service Company: W. D. Williams.
Puget Sound Power & Light Company: H. A. Gardner.
Utah Power & Light Company: L. B. Gawan.
The Washington Water Power Company: L. V. Ross.

much help from the home magazines and from the movies. The central stations can benefit from this urge and from the imitative reactions of the friends of our employees in the way of a better consciousness of and desire for good house lighting. People are anxious and willing to learn what is best, when their comfort is enhanced. Between 1½ and 2 per cent of the customers of some of the central stations are employees who are heads of families. The rank and file of employees should be encouraged to beautify their homes by shading all lights by home-made shades, if necessary, and by reduced prices on modern and scientific equipment. The officials and executives in their homes should be thoroughly up to date in all their lighting appurtenances. Many more of our customers are represented by at least one member of the family among central station employees. While this percentage may be less with those utilities who are not also operating street railway systems, it still reaches a fair sized total.

In connection with this thought, the Pacific Northwest Public Service Company is preparing a course on home lighting to be given through the women employees' organization, to those women who are found to be interested. We hope in this way to acquaint the women employees with what is desirable and best in home lighting equipment, knowing full well that the best and desirable level is well above the average level at present. That these women are receptive to this information is shown in the fact that recently they put on the playlet "Lit Up" at one of their meetings. A great deal of interest was aroused by the playlet and they have been requested to repeat it.

Other Methods of Promotion

Talks on home lighting have been presented before business and professional women's clubs, before parent-teachers associations and before home economics classes in the state colleges.

In Seattle time has been reserved for broadcasting home lighting talks over the radio.

An article on home lighting was requested by one of the Portland newspapers, and it is now in the process of preparation and will soon appear in the Sunday edition.

New Applications in the Home

Modern home lighting does not consist merely of overhead ceiling fixtures and portable lamps. The growing appreciation of color interest spots in a room, light ornaments designed to be especially beautiful at night, and the use of colored lights for atmosphere are becoming more and more noticeable. These light ornaments are as good for load as a vacuum cleaner. Colored lamps are very inefficient as a means of producing light for any purposes of close application such as reading or sewing. Thus other white lamps must be burned in addition.

Outdoor lighting at Christmas time is ushering in the feature of outdoor lighting all the year round. Garden lighting has been attempted in many quarters and offers a field for increasing residential use of kw.-hr. Beautiful bushes in their seasons can be lighted by portable angle-type reflectors, and many beautiful effects have been achieved.

Small electrically lighted fountains in the yard can be erected at small cost. A pipe from the outdoor water connection for a jet or spray, a water-tight glass covered compartment from which a spot of light or a flood of light can be directed upwards through the jet or spray is easily constructed. A color wheel can be made to revolve over the light source and a continuous change of color be obtained.

A new departure in residence lighting is the illuminated house number, either with 110-volt lamps behind a glass panel on which the number is painted, or 6-volt lamps fed from the door bell transformer, which burn all the time. There are Neon house numbers also.

We have all probably had the experience of trying to locate the home of a friend at night. Not knowing the exact location except the house number and street, how often have we driven up and down the street, or tiptoed up to several houses searching for the hidden number before finding the right house.

One new residence in Portland installed, at our suggestion, a key-hole light. A push-button in the door jamb operates a small light through a bull's-eye onto the key hole, so in the dark the key hole is easily located. In Europe where telegraph companies are government owned, there have been laws passed, requiring that houses have illuminated house numbers to assist the telegraph boys and physicians in finding the correct house at night.

Overhead eave lights to flood the grounds in case of prowlers at night, can be utilized also for garden parties.

A new type of floor lamp just coming into favor and mentioned before is the totally indirect urn lamp. This light is a further development from the Duplexalite portable and the Curtis adapter unit. All of the light goes to the ceiling where it is redirected about the room, eliminating all of the harsh contrasts from the portable lamps, and is very effective in heightening the cheer and comfort of the entire room. For bridge parties these lamps are particularly effective as no glare whatever is present on the cards. The miscalled "bridge lamp" is notorious in its casting such a glare on at least one player's cards that it frequently is a mystery to him whether his cards are clubs or diamonds. These lamps utilize 200 and 300-watt lamps, which is a very desirable feature in connection with them.

People must have impressed upon them the fallacy of purchasing beautiful furniture, rugs, draperies and pictures, and then bottling up their beauty with inadequate or improper lighting. They can well afford to spend a few cents additional each evening for electricity so that they and their friends can more fully appreciate the values and excellence of their taste in home furnishing. They can get all the "atmosphere" they desire and still have sufficient well directed and well diffused light for all their needs.

Refixturing

Refixturing campaigns have been tried out with varying degrees of success. One company has been quite successful with campaigns featuring floor and table lamps producing illumination of high quality, such as Duplexalite lamps and the new Luckiesh-Miller lamp.

The type of lamp bearing the stamp of approval of the best engineering practice is the only kind that a central station can safely promote and be consistent with its aim of giving the customer correct and scientific lighting. These better types of lamps are being imitated more and more by other manufacturers and many really good lamps can now be found in first class department stores.

Ceiling fixtures have not been so successfully merchandised because of the customers' antagonism toward the old type unit and the lack of really good, high quality fixtures embodying correct principles. The modernistic trend will no doubt develop something first class, and it is getting very close to the goal. Good

sales appeals for ceiling fixture campaigns are ready when the right fixture appears.

Some of these appeals are as follows:

1. Old fixtures are out of date. Get modern.
2. New fixtures will look better and make for more cheerfulness. (These two appeals, however, can be put off by the customer who might say "later on, perhaps.")
3. Save your eyesight, and the eyesight of your children. (This appeal calls for immediate action. All three appeals should be used but special stress placed on the last one.)

The same appeals can be used in selling any of the better lamps on which campaigns have been run.

Summarizing

A 60-watt lamp additional per customer will bring in approximately $1 per year increase per customer.

The better grade of lamps use wattage much higher than this.

The residential lighting load brings in about 29 per cent of the entire central station revenue.

The average home is only 50 per cent well lighted.

People are spending money for fine furnishings and can be brought around to spend a little more to enhance the appearance of these furnishings. Good light is not expensive compared to other outlays.

It is the obligation of the electrical industry to educate its customers to the vital need of conservation of eyesight for themselves and children. The average individual does not sense this condition.

People, however, are receptive to instruction and advice but masses move slowly, and old habits must be overcome.

Qualified personnel should be provided to advise with customers on home lighting questions and to assist in making the lighting layout on new home plans.

By means of talks before women's clubs, newspaper and magazine articles, radio talks and playlets, this message can be put across.

The women employees of the central stations will form a fine nucleus and bridge-head from which to disseminate further the story of adequate lighting, and employees should be encouraged by special price features to modernize the lighting in their own homes.

Last but not least, there is a large plum of additional revenue awaiting the picking.

MERCHANDISING BUREAU[2]

*Promoting the Sale of Electric Ranges**

PROBABLY no other phase of central station selling activities has been discussed as much as the promotion and sale of electric ranges. During the past few years reports covering practically every phase of the electric range business have been submitted by committees of this association. Each year new problems arise that continue to make this an important and interesting subject. When we consider that, in spite of the enormous amount of sales and promotional effort put forth to promote this business, many companies actually are showing a decrease in electric range sales in proportion to the money and effort expended, it would seem that there is plenty of room left for discussions.

In consideration of this condition, this committee has undertaken to present this subject purely in the light of an analysis of market possibilities and to ascertain the factors responsible for the lack of comparative results obtained through the past year's selling operations. In addition to this, we have attempted to suggest certain steps which could be taken to correct these factors.

When we consider that the present range saturation in the Northwest is less than 30 per cent of the wired homes served by the utilities represented, we can readily realize the tremendous market left undeveloped. Again, when we consider the increase noted in the sale of other appliances which have reached a far greater saturation point than the electric range, we are led to believe that there must be fundamental factors influencing the sale of electric ranges which must be considered before electric range sales can be placed on a basis comparable with other appliances.

Our investigation brings to light eight major points, all influencing more or less the sale of ranges. While some of the organizations represented here have corrected a part of these conditions, we believe that no organization has been successful in eliminating all of the eight major points of sales resistance.

1. Initial Cost of the Electric Range

The initial cost of an electric range always has been a major factor in range sales resistance, because of the fact that gas or fuel ranges can be purchased at a much lower figure and at practically the same terms. Present prices of ranges large enough to accommodate a fair-sized family, when combined with water heater, tank cover and switch, are out of reach of the majority of people. While it may be said that the price of the electric equipment is not important as long as the monthly payments are within reach of the average income, it must be considered that gas and fuel ranges are sold on the same basis and that each of the manufacturers of such equipment has a story to tell which makes his product inviting to the customer.. We feel sure that a substantial decrease in the list price of the electric range would result in the same reaction as experienced by the manufacturer of washing machines, automobiles, radios and so forth. Our first recommendation is to encourage the production of a range, adequate to meet the needs of the average family at a price within the means of the masses. Such a range at that price, with present credit facilities, would enable the mass of people to purchase electric cooking equipment. Price, however, is only one of the factors to be considered.

2 and 3. Operating Costs and Education of Customers

There is a feeling prevalent among those customers who make up the potential market with which we deal, that the cost of operating an electric range is high. This idea has been brought about, first, through lack of knowledge and, second, through user advertising. This user advertising may have come from satisfied customers who were well able to afford service bills resulting from their own range operation. This same

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[2] R. M. Bleak, Utah Power & Light Company, chairman.

* Report of the domestic electric range committee. G. L. Jackson, The California Oregon Power Company, chairman.
Edison Electric Appliance Company: Ralph Cordiner.
Northwestern Electric Company: J. B. Buman.
Utah Power & Light Company: W. M. Moreton.
Westinghouse Electric & Manufacturing Company: E. V. Peterson.

service bill might seem low to most of the customers who now operate electric ranges but would seem high to the mass of wage earners and people in more moderate circumstances with whom we must deal in the future. Advertising through any medium, dealing with operating costs, would not overcome this situation because user advertising is the strongest advertising we could possibly have. Therefore, an effort must be made to change this user advertising to a point where it will promote rather than retard the sale of electric ranges. In our opinion, it would be a waste of money for any utility to try to sell by means of advertising, the idea that electricity is cheap if it did not have the proper type of user advertising to substantiate the statements made. We believe, that through education in the proper operation of the electric oven and range accessories such as the cooker, that present customers could and would reduce their operating costs considerably, and in the reduction of that operating cost would become better satisfied users of our service. Through lower operating costs, user advertising would place electric cooking on a cheaper operating basis, thus largely offsetting the prevailing idea that electric cooking is too high.

When a housewife uses the cooking surface of an electric range for 65 or 75 per cent of her cooking operations the kw.-hr. consumption is bound to be high because of the heat loss involved in the use of surface units. If, on the other hand, the oven is properly used, the kw.-hr. consumption can be decreased substantially and customer satisfaction increased proportionately. After all our advertising and sales promotion work, it is surprising how few housewives actually use an electric range efficiently. For instance, the oven can be used to cook as many as four different kinds of food in one operation. Yet how many customers do you find using the electric range oven in this way? This condition is due to two things: lack of instruction in the use of the electric range oven, and the lack of adequate utensils for using the oven for more than one operation at a time. We must, therefore, consider the education of all present users of electric ranges in the proper use of oven and auxiliary cooking equipment for the following reasons:

1. Reduction of operating costs.
2. Better satisfaction with cooking results obtained.
3. User advertising resulting from points Nos. 1 and 2.

This can best be brought about through personal contact on the part of employees who have been schooled in such work. Methods of carrying on this educational program will, no doubt, vary in each locality. Many companies have maintained a home service department for several years, contacting customers who have purchased new ranges, with the idea of educating them to use the range properly. However, some companies do not follow this practice and assuming they do, types of equipment and methods have changed so much in the past few years that a great deal of good could be accomplished by contacting these customers again. For quick results it is suggested that a crew of girls be organized and educated with this idea in mind and that every range user now served by the utility be interviewed or given a demonstration in their own home, as the case may require. Through these personal contacts the following things could be accomplished, aside from the educational program referred to:

1. A service check on ranges in use.
2. A tremendous amount of good-will could be gained, not only for the utility itself, but for the use of electricity in general.
3. Such a plan could be used to advantage in carrying out the "work the user" idea in range sales promotion.

4. Service

Unlike gas or fuel ranges, electric ranges require a considerable amount of repair and partial replacement from time to time. This, of course, must be added to the cost of operation. Due to the fact that this service costs money, many customers are using electric cooking equipment not in good operating condition. Many customers have failed to turn in complaints on low voltage and general service; burned out elements, switches failing to work, automatic controls out of adjustment, elements too slow to heat, and many other minor troubles which should be taken care of if it were not for the fact that the customer feels that this may cost money and is consequently reluctant to call upon the central station or contractor-dealer for service. This condition has been a very important factor in slowing up range sales. The range business, from a utility standpoint, is strictly a load-building program. In order to place electric cooking on a competitive basis with other fuels, the service problem must be given serious consideration since it is an addition to the cost of electric cooking, as well as being of considerable inconvenience to the customer.

Most central station merchandise departments guarantee an electric range for one year. This guarantee does not apply after the one year has elapsed nor does it apply on ranges sold by other stores who might not be equipped to service them. Satisfactory results cannot be obtained when a range is not in first-class operating condition and unless we can show satisfactory cooking results through the medium of electricity, we cannot hope to increase this class of load to any great extent. Servicing, therefore, becomes a utility problem as well as is merchandising. The committee feels that the utility would be justified in extending free service on all kinds of electric ranges regardless of make. It has been suggested that, in order to decrease the cost of such service to the utility, the customer be billed for the cost price of the parts only—labor free. When considered in the light of the value of the electric range load, this policy certainly could not be regarded as out of line with good business.

5. Interesting Other Organizations Such as the Hardware Store and Furniture Store in the Sale of Electric Ranges

There has been a tendency on the part of central station selling organizations to eliminate, insofar as possible, competition through contractor-dealers, hardware stores, furniture stores and department stores, with the idea of increasing their own sales through exclusive distribution. When a prospective buyer contemplates the purchase of new household equipment, the furniture store or the department store is probably the first place contacted. These outlets, as a rule, do not handle electric ranges, or do not push the sale of them because of the small amount of profit involved. They have received very little encouragement from the central station to sell electric ranges and even though they were encouraged to sell, it would be necessary for them to take on some off-brand which is practically unknown to the community.

Discounts on fuel and gas ranges, to the independent outlet, are from 10 to 30 per cent greater than on electric ranges. It is no wonder then that furniture, hardware or department stores prefer to sell other types of cooking equipment rather than to pioneer some

new make of electric range in competition with the central station. In addition to this, they must assume the guarantee from the service standpoint if they expect to continue selling electric ranges. We can readily understand, then, why we are not receiving the support of such organizations in merchandising electric ranges. In other words, the central station is practically in possession of the range selling field insofar as those of the electric type are concerned and with that possession must assume the full responsibility for the promotion and sale of their product without help, assuming at the same time all the competitive factors arising out of such a condition.

Radios, musical instruments, automobiles and other items have become popular because of intensive advertising and wide distribution from a retail standpoint. In the case of electric ranges, the tendency has been for the central station to assume the distribution of this product to the exclusion of all others. This situation has arisen perhaps because of a feeling that it was necessary to create a large volume of business through their own organization in order to justify the service arising out of the sale of such equipment.

If electric ranges are to take their place as one of the major household necessities, channels of distribution must be increased. An effort must be made to interest the furniture dealer, hardware dealer and the department store, now handling other types of cooking equipment, in the sale of electric ranges. It must be considered, however, that since the margin of profit involved in the sale of an electric range is so much less than that on a gas or fuel range, it is going to be necessary to make some arrangement to equalize discounts if we expect to interest these dealers. It is suggested that in addition to encouraging these outlets to merchandise electric ranges, an effort be made to increase the discounts, even though it is necessary to pay a premium on sales made through these sources, charging this amount to new business expense.

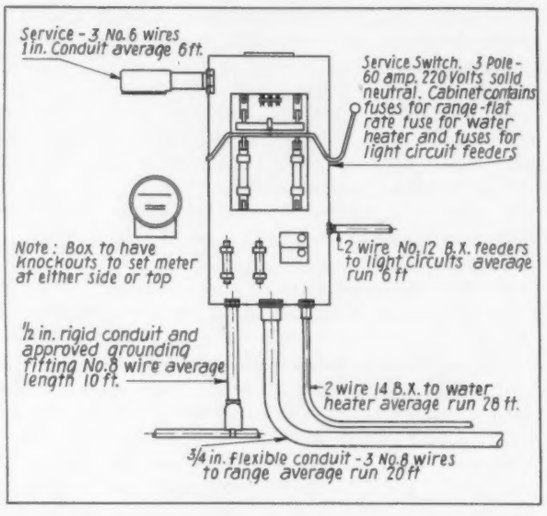
6. Proper Education of Salesmen and Contact People

Successful washing machine salesmen, refrigerator salesmen and vacuum cleaner salesmen, could never hope to succeed with no more knowledge of their product than that possessed by the average range salesman or the general salesman on whom we depend for our range sales. Knowledge of the product which we sell is one of the primary elements of salesmanship, yet it is surprising how little the average salesman or contact person actually knows about an electric range. Housewives are interested in saving labor, better cooking results, and new methods of food preparation, not in the mechanics of the range. Inasmuch as the sale of an electric range deals with the fundamentals of household economics, salesmen must be able to talk in terms of electric cooking rather than mechanics. They must be familiar with every phase of electrical food preparation. We feel that every salesman and saleswoman should be given a thorough education in the subject of "cooking by wire." More stress should be given to home service work. To begin with, the home service department should carry on educational work among our own employees, giving them proper instructions on all phases of electrical cookery. The more intelligent the contacts which we make, the more successful our range business will become. In this connection we call your attention to an article headed "Unknown and Unwanted" by W. L. Frost, commercial manager of the Southern California Edison Company, published in the February, 1930, issue of *Electric Light and Power*. This article brings very forcibly to our attention, the need for more intelligent contacts and proper education of contact people.

7. Wiring

Special wiring, required for a range installation, always has been a stumbling block in the sale of electric ranges, since the majority of homes are not wired for such service. To make this problem even more difficult, we find that the potential market with which we must deal in the future is composed of a large portion of customers living in rented homes in which the householder does not feel justified in investing additional money for wiring purposes. The price of range wiring installations has been on the up-grade for the past few years and instead of wiring becoming a decreasing factor in the sale of ranges it has evolved into a more important point. Our big problem in the future is to overcome high wiring costs and to make it possible for renters to own and operate electric ranges.

Most rented homes are old buildings in which the landlord is averse to making an additional investment. At the same time, the renter does not feel justified in spending $35 or $40 for a wiring installation which ultimately will become the property of the landlord. Our only possibility at present for overcoming this problem is to work up some sort of a portable wiring installation which can be sold as part of the range and which can be moved when necessary without exorbitant cost. We are submitting herewith a diagram of a proposed portable wiring installation that will cost approximately $35 installed. (See Fig. 1 with specifica-


Service - 3 No. 6 wires 1 in. Conduit average 6 ft.
Service Switch. 3 Pole - 60 amp. 220 Volts solid neutral. Cabinet contains fuses for range - flat rate fuse for water heater and fuses for light circuit feeders
Note: Box to have knockouts to set meter at either side or top
2 wire No. 12 B.X. feeders to light circuits average run 6 ft
1/2 in. rigid conduit and approved grounding fitting No. 8 wire average length 10 ft.
2 wire 14 B.X. to water heater average run 28 ft.
3/4 in. Flexible conduit - 3 No. 8 wires to range average run 20 ft

Details of portable heavy-duty wiring installation. Specifications of material are given in the tabulations immediately below

Equipment Specification for Portable Installation

1. One A.G. combination two-circuit cabinet, catalog No. HP-302-RTN, including:
   - One 60-amp. 3-pole solid-neutral switch.
   - Two lighting circuits.
   - One range circuit.
   - One water heater circuit.
   - Fuses for each circuit.
2. Miscellaneous equipment and supplies:
   - One 1-in. nipple with Condulet and cover for service entrance.
   - Twenty feet of ¾-in. flexible conduit with three No. 8 wires.
   - From 20 to 40 ft. of BX No. 2 for water heater.
   - Meter loop at either top or side of cabinet.
   - One ground clamp.
   - Twenty feet of ½-in. conduit for ground wire.

All fittings must be attached in place and all wires pulled into place. This installation must be mounted in all cases with screws to facilitate its easy removal.

tions.) Subsequent installations can be made at a price varying between $3 and $10. This proposed portable wiring installation conforms with the State and National wiring codes and can be used in every district in Oregon, with the exception of Portland, where it will be necessary to increase the size of the conduit to 1¼ in. for the service wires and to 1 in. for the range lead. The switching equipment can be placed on a large board and hung with two hooks and the flexible conduit or rigid conduit, as the case may require, can be fastened to the house with screws and clamps, being very easily removed when desired. This installation not only meets the requirements of the wiring code but the requirements of law in moving equipment of this type from rented houses. This installation can be sold as a part of the range and can be reclaimed on reverted contracts just as the range itself.

8. ADVERTISING

Let us again call your attention to the previous mentioned article, "Unknown and Unwanted." This article bings out forcibly the fact that electric ranges still are practically unknown to the masses and that the little which actually is known is negative insofar as the industry is concerned. We have accomplished very little toward selling the electric range idea in general. Our advertising has been confined to the two or three types of electric ranges we handle, bringing out the merits of those particular ranges over all others. Our only hope for the success of this program must be in making electric cooking a by-word and to do this we must first overcome the obstacle, "Unknown."

It is recommended that an advertising program such as sponsored by the ice manufacturers, refrigerator manufacturers, laundry associations, and so forth, be inaugurated in the Northwest, supported by central stations and manufacturers represented in this territory—this advertising to tell the story of electric cooking in all its phases without reference to any particular brand of electric range. Such a program will result not only in a better public acceptance of electric cooking, but also will be an encouragement for other outlets to merchandise an article which is of prime importance to us from a load building angle. It is only through concentrated advertising and intelligent contacts that our major obstacles "Unknown and Unwanted" can be overcome.

*Water Heating**

PRACTICALLY every electric utility can heat water electrically on a basis profitable to the utility and acceptable to the customer. That many who are not now doing it can do so is shown by those companies who already are actively in the business with rates that are returning as high as $80 per system kw.-yr. which, after all, is the important consideration to utility investors rather than the price per kw.-hr. To date many companies have looked with disfavor on this business, thinking that the necessary rates would be low per kw.-hr. and not having figured the return on a kw.-yr. basis. Customer acceptance of the water-heating idea where full automatic service is being rendered is, in the opinion of this committee, a clear indication that in the near future this service will be demanded of public service companies that now are not prepared to render this service.

Cold-water supply has been simplified the country over, requiring only the opening of a faucet to secure the service. Similar service for hot water will be demanded and can be supplied. Realizing the mass of test data already available covering the multitude of details that enter into this problem, this committee considers that there is little need for any further testing. This committee, after its general survey of the situation, finds that in communities where electric water heating is being done successfully that one kilowatt of capacity working approximately one-half of the time is giving satisfactory service to the five- or six-room home, which represents approximately three-fourths of the market.

Naturally the water-heating program of any company will have to be worked out to conform to the peculiarities of the particular power supply system. If the company has a large industrial day load and a relatively light night load, it may be decided to do the water heating between the hours of 7 p.m. and 7 a.m., employing of course the proper apparatus for this operation. If, however, the system shows a high daily load factor, the use of electricity for water heating could be spread over the 24-hr. period by the use of low-wattage installations.

Once the water-heating system has been selected, which best suits the needs of the particlar community being studied, the next step is to select equipment from available apparatus already perfected and on the market.

This committee is convinced that, particularly in the initial stages, this water heating program cannot be carried on successfully merely as an additional duty of some existing department, but must be studied and promoted by men giving their entire working time to the problem.

While this committee has attempted to confine itself to the subject of electric water heating, it feels that attention should be called to the fact that the goal should be the completely electrified home and that water heating because of its relatively large current consumption and its substantial financial yield should be made a very important part of the program of complete home electrification.

This committee is well pleased with the growing popularity of rates for complete home service measured by a single meter and thinks that the progress of water heating will be much more rapid if total residence service and total bill are discussed rather than the practice that has obtained of attempting to justify cost in competition with other water heating methods.

Companies that have done a good job of promoting electric water heating are reporting that customers seem more willing to accept the total bill for total service than they are to accept the cost of water heating only, segregated and discussed as a separate item.

* Report of the water heating committee. L. W. Brainard, Idaho Power Company, chairman.
Idaho Power Company: J. B. McLain.
Northwestern Electric Company: A. D. Leach.
Utah Power & Light Company: H. M. Ferguson.
The Washington Water Power Company: R. B. McElroy.

*Electric Refrigeration**

PREVIOUS reports of the electric refrigeration committee have dealt with many phases of the subject, particularly the desirability of the load and the

* Report of the electric refrigeration committee. J. B. Buman, Northwestern Electric Company, chairman.
The California Oregon Power Company: G. L. Jackson.
Idaho Power Company: F. M. Ingraham.
Puget Sound Power & Light Company: J. E. McIver.
Utah Power & Light Company: J. F. McAllister.

problem of service. This year the committee has been asked to present sales information that may be of some value to central stations desirous of promoting refrigeration sales.

To make the report more comprehensive, questionnaires were sent not only to fourteen companies in the Northwest geographic division, but also to fifteen companies in the Middle West and South. While the questionnaire covered considerable ground, the report will deal only with facts expected to be of particular interest or value to the Northwest companies.

In general, it appears that electric refrigeration ranks high in interest among central station men because of its high load factor plus the fact that, once placed on the lines, it is definite and continuous in kw.-hr. consumption. We must conclude that the question of whether to sell or not to sell electric refrigerators lies within the merchandising policy of each company.

Of the fifteen member companies in the Pacific Northwest, six do not merchandise electric refrigerators. Of the nine which do sell refrigerators, only four appear to make them a major part of their merchandising program. Twelve of the companies in the Middle West and South report that they make a very aggressive effort to build this type of business. In the case of those companies that have sought to sell refrigerators aggressively, this appliance has represented a large portion of the year's merchandise sales.

It is noted from the questionnaires that the Northwest companies that are selling refrigerators have been active only on an average of two years, except one which has been in the business for six years and another for four years. Companies reporting outside this territory have been active on an average of four years. Sales methods of all these companies seem to be somewhat similar in that the salesmen in small towns sell refrigerators along with the general line of appliances, while in the larger cities a separate refrigeration sales organization is set up.

A summary of some of the answers to the questions asked follows:

Profits and Saturation

In the matter of refrigeration sales being a financial success from a merchandising standpoint, seven reported in the negative, six in the affirmative, with one uncertain.

Answers as to the percentage of commercial sales made in comparison to domestic, show that practically all effort has been on domestic refrigerators, none of the companies reporting more than 5 per cent commercial sales. Several companies indicated their intention of becoming active during 1930 on commercial machines.

Answers as to the relative percentage of saturation from the power company's own sales efforts for the past three years indicate, where the information was furnished, a decided increase each year, the average being from 1 per cent the first year to 2.8 per cent in 1929.

On the point of the use of refrigerators by employees in their own homes, it was found that among large companies aggressively selling refrigerators there was a saturation of employee use of from 10 to 15 per cent. Other companies reported a much lower percentage.

Prices and Terms

The question of price maintenance seems to be well established in practically all companies. Factory list is used as the cash price. Considerable variation is shown, however, in the carrying charge added for time contracts. These charges range from 6 per cent to 10 per cent added to list price. In a few cases 0.5 per cent per month is used, but 8 per cent of list is used in the majority of cases. Competition and local conditions probably have considerable to do with establishing carrying charges.

A question as to the time allowed on term payments brought out the fact that a majority offered a 24-month contract. One large company in the Northwest offers a 30-month contract. Since the question brought out no unfavorable comment, it is assumed that contracts of this length represent sound practice. In the advisability of using the mid-winter deferred payment plan, sixteen companies expressed themselves as decidedly against, while five reported favorably.

Salesmen's Performance and Compensation

In an endeavor to learn what volume could be expected of salesmen and at what expense, questions were asked pertaining to the number of units sold per man per year and as to the compensation paid to salesmen.

These questions brought a wide variety of answers from which little can be determined, because of numerous companies having salesmen selling the entire merchandise line. Sales vary from 26 to 168 per salesman. The average from eleven reporting companies is 70. Some companies set up a quota of 60 units per salesman in metropolitan areas. Similar variations were shown in the matter of compensation to salesmen, ranging from $150 to $293 per month. The average for these is $192.

Advertising

Answers to questions about advertising show the daily newspaper to be considered as the best medium. Most of the companies spend practically 75 per cent of their refrigeration advertising budget with their local papers. Other advertising media used are direct mail and billboards. Policy seems rather clearly defined as to the percentage of advertising expense to gross sales, most companies allowing about 3 per cent.

For the most part, little or no effort is made to take advantage of such natural advertising sources as school cafeterias, church social halls or similar institutions, other than offering a slight discount to such institutions on the purchase of a refrigerator. The committee believes that a little sales effort in these places would bring continuous results in an advertising way because of the continually changing personnel reached and the fact that most of them are women.

Food Preservation Campaign

Practically all of the companies put on seasonal campaigns to obtain 65 per cent or more of their year's business, having two or three campaigns, each of about six weeks duration.

The last question of the questionnaire was: "Were you satisfied with the results obtained in your locality from the National Food Preservation Publicity Campaign?" Of those answering, twelve reported that they were not satisfied, six answered, "Yes," some advising that such a campaign be put on every year.

Potential Field is Large

For the comparatively brief time that electric refrigeration has been aggressively sponsored by dealer or power company, it is the opinion of the committee that rapid strides have been made and that the near future presages a greater volume of business at lower costs.

Statistics available previous to the advent of mechanical refrigeration show that little thought has been given to refrigeration in the average home. The promotion of mechanical refrigeration has brought on a new order of affairs, and the necessity for the consideration of the care of foods for the family is better understood.

The potential field for refrigerators has been untouched, practically speaking. The dealer and salesman have a large field in which to expand and, with the application of earnest effort, good results may be obtained. It seems needless to dwell upon the necessity for organization and trained salesmen for this business. That must be a foregone conclusion to those who have tried to get the business.

Refrigeration has been accepted by the majority of utilities as a desirable load due to its diversity and the relation of kw. connected to the property investment. Refrigeration is a good-will builder and usually the purchasers are enthusiastic with the results obtained.

In conclusion, the committee offers a few suggestions, some of proved value, others for consideration.

Recommendations

The refrigerator is of such value to every power company as a load builder device that the committee feels warranted in recommending a certain amount of activity by all companies whether or not they are committed to a policy of merchandising the appliance. For those companies not merchandising the device, it is suggested that thought be given to carrying an electric refrigeration display and, in addition, to allotting a reasonable portion of yearly advertising budgets to promoting proper refrigeration in the home.

Contests are old, but proved, methods of creating interest in a forward movement. Essay contests among company employees for the best series of essays would be productive of considerable interest. A large number of prizes is better than a few large ones to bring in as many contestants as possible from all departments of the company.

Employee contests probably could be successfully followed by a 30-day prospect contest, in as much as a great number of employees would be particularly well informed on the merits of proper refrigeration and eager to test their ability to create interest in others.

Essay or oral contests can be offered to registered high school students. Contests of this kind should be sponsored by all those interested in the refrigeration business.

In order to obtain widespread results, there must be a widespread and continuous effort on the part of those interested to dispense information on the proper preservation of food. The woman's page is an economical and often overlooked agency in our newspapers and similar periodicals. Co-operation of this agency can best be secured through the company advertising department working in conjunction with the domestic science department of the publication. This is done now by some companies in the summer season. It is recommended that information on the care of food and on the new frozen recipes and dainties made possible by an electric refrigerator be put prominently in print the year round.

By our own actions we are inclined to believe, and lead others to believe likewise, that only in the summer is there a drastic need for real refrigeration, when as a matter of fact we are aware that food spoils about as readily at one time of the year as another. For this reason, our advertising copy should stress the electric refrigerator as a necessity in every family kitchen, if food is to be kept safe and nutritious at all times. A refrigerator to keep food in should be shown to be as important as an electric range to cook it properly. Such a slogan as "The climate at any time is a poor substitute for proper refrigeration," or "The old cupboard is replaced by a modern refrigerator," can be used advantageously in all copy to overcome the commonly prevalent idea that food deteriorates only in summer heat.

A page may be taken from the book of our early experience in range sales. Formerly we advertised and sold practically all of our ranges in the summer season, putting all our weight of copy and sales talk on a cool kitchen. Today we have five definite reasons why the housewife should cook by electricity. We advertise and sell twelve months in the year and have almost eliminated the deep valley in our sales curve which used to occur in the winter months.

Our efforts should tend more toward inculcating in the minds of our customers and those responsible for sales the idea that an electric refrigerator should be a part of the equipment of every housekeeping establishment.

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*General Merchandising**

WHEN the chairman of the merchandising bureau, formulated plans for organizing his work, he appointed committee members from the so-called "firing line." With this in mind, this committee has attempted some original thinking in an attempt to present a viewpoint of the merchandising problem from the standpoint of men actually engaged in it and making daily contacts with the actual selling process. After some correspondence between committee members on the subject, a meeting was held in Portland on Dec. 13, 1929. At the close of that meeting, each member was assigned a specific subject for further study. The report of this special study by the several members has been consolidated and represents the basis for this report. This report will attempt to present factors of importance in the order in which they appear in any merchandising plan:

1. The need for executive interest.
2. The necessity of a well organized merchandising plan.
3. Some essential factors with reference to the merchandise itself.
4. The problem of employee participation in merchandising activity.
5. The training of salesmen for public utility merchandising.

1. The Need for Executive Interest

As merchandising programs grow from small beginnings, there are needed larger amounts of money, more salesmen from the operating organization, greater participation by operating employees and considerable encouragement by the sales personnel. It is believed, therefore, that executive interest is a necessary part of any well balanced merchandising program. By active interest is meant that there should be a personally

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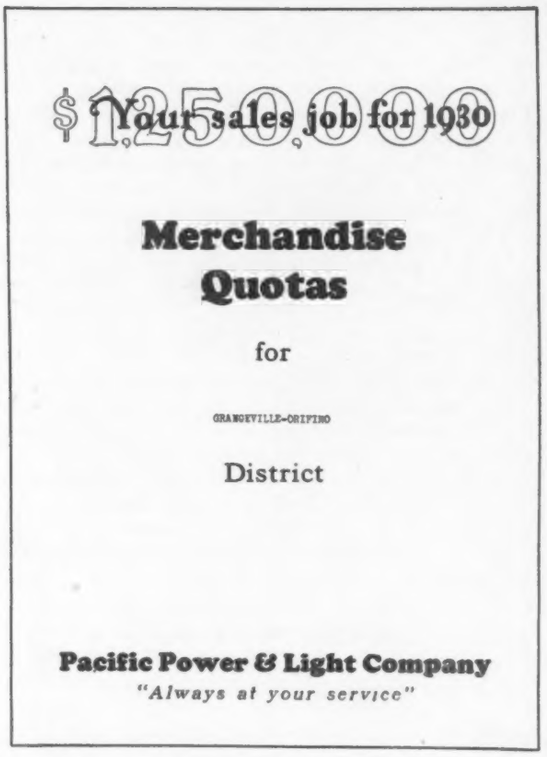
* Report of the general merchandising committee. H. W. Cooper, Pacific Power & Light Company, chairman.
Idaho Power Company: J. F. Cooper.
Mountain States Power Company: H. D. Kem.
Northwestern Electric Company: H. C. Siegfried.
Pacific Northwest Public Service Company: G. W. Madison.
Utah Power & Light Company: G. B. Earl.



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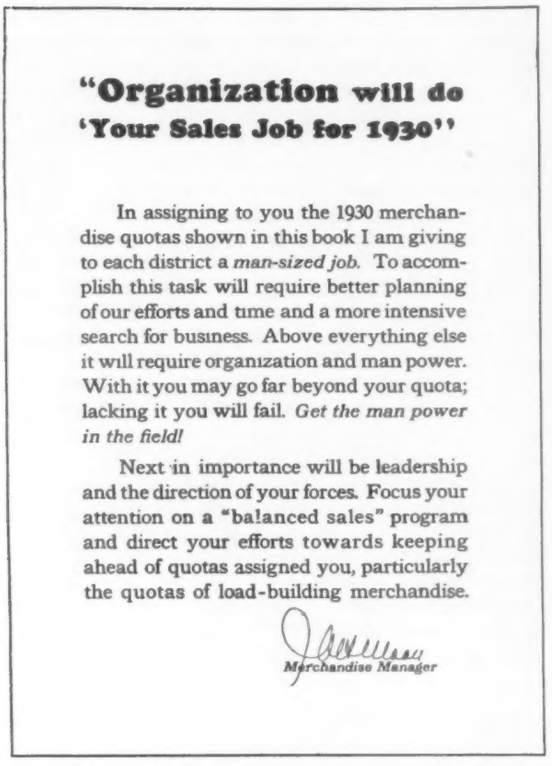
initiated interest in sales activities by all executives from the most important down to those with only a limited responsibility. It is believed that the Association members are fortunate in having, to a marked degree, this active executive interest.

2. The Necessity of a Well Organized Merchandising Plan

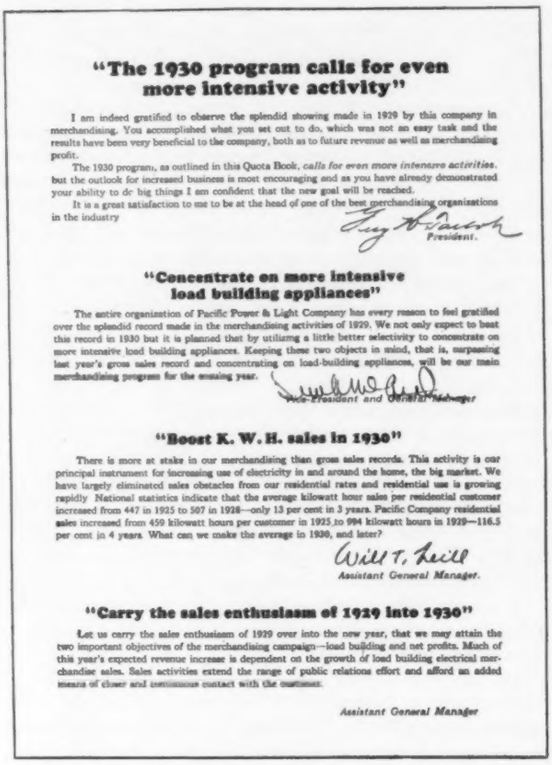
Every organized business makes some sort of a budget of what it expects to do in the future. Preparation of a merchandising plan is nothing more than budgeting future work. The committee solicited each member company with a view of having each present a copy of their formulated plan for the 1930 activity. As usual, answers were not obtained from all of the members, but, for the purpose of this report, samples are presented of at least two which seem to be very complete in all details. A successful plan must:

1. Solicit executive interest.
2. Provide a picture of the entire plan.
3. Contain individual units of activity so that individuals may appreciate their personal possibilities.
4. Contain units of time for concerted effort on particular appliance sales.
5. Provide some sort of incentive to those individuals whose duty it is to carry out the plan—for example, pictures, charts, games, and other similar visual devices for arousnig and maintaining interest.
6. Provide a method of recording actual results and comparing them with the budget or quota.

Samples of the merchandising plans of two Northwest companies are given in the illustrations accompanying this report. In the first 19 illustrations are shown the pages of the 1930 Merchandise Plan Book of the Pacific Power & Light Company. The remainder of the illustrations depict the 23 pages of the Plan Book of the Portland Electric Power Company.


"Organization will do 'Your Sales Job for 1930'"
In assigning to you the 1930 merchandise quotas shown in this book I am giving to each district a *man-sized job.* To accomplish this task will require better planning of our efforts and time and a more intensive search for business. Above everything else it will require organization and man power. With it you may go far beyond your quota; lacking it you will fail. *Get the man power in the field!*
Next in importance will be leadership and the direction of your forces. Focus your attention on a "balanced sales" program and direct your efforts towards keeping ahead of quotas assigned you, particularly the quotas of load-building merchandise.
Merchandise Manager

Page 2 of Pacific Power & Light Company's 1930 Merchandising Plan Book


"The 1930 program calls for even more intensive activity"
I am indeed gratified to observe the splendid showing made in 1929 by this company in merchandising. You accomplished what you set out to do, which was not an easy task and the results have been very beneficial to the company, both as to future revenue as well as merchandising profit.
The 1930 program, as outlined in this Quota Book, *calls for even more intensive activities,* but the outlook for increased business is most encouraging and as you have already demonstrated your ability to do big things I am confident that the new goal will be reached.
It is a great satisfaction to me to be at the head of one of the best merchandising organizations in the industry
President.
"Concentrate on more intensive load building appliances"
The entire organization of Pacific Power & Light Company has every reason to feel gratified over the splendid record made in the merchandising activities of 1929. We not only expect to beat this record in 1930 but it is planned that by utilizing a little better selectivity to concentrate on more intensive load building appliances. Keeping these two objects in mind, that is, surpassing last year's gross sales record and concentrating on load-building appliances, will be our main merchandising program for the ensuing year.
Vice-President and General Manager
"Boost K. W. H. sales in 1930"
There is more at stake in our merchandising than gross sales records. This activity is our principal instrument for increasing use of electricity in and around the home, the big market. We have largely eliminated sales obstacles from our residential rates and residential use is growing rapidly National statistics indicate that the average kilowatt hour sales per residential customer increased from 447 in 1925 to 507 in 1928—only 13 per cent in 3 years. Pacific Company residential sales increased from 459 kilowatt hours per customer in 1925 to 994 kilowatt hours in 1929—116.5 per cent in 4 years. What can we make the average in 1930, and later?
Assistant General Manager.
"Carry the sales enthusiasm of 1929 into 1930"
Let us carry the sales enthusiasm of 1929 over into the new year, that we may attain the two important objectives of the merchandising campaign—load building and net profits. Much of this year's expected revenue increase is dependent on the growth of load building electrical merchandise sales. Sales activities extend the range of public relations effort and afford an added means of closer and continuous contact with the customer.
Assistant General Manager

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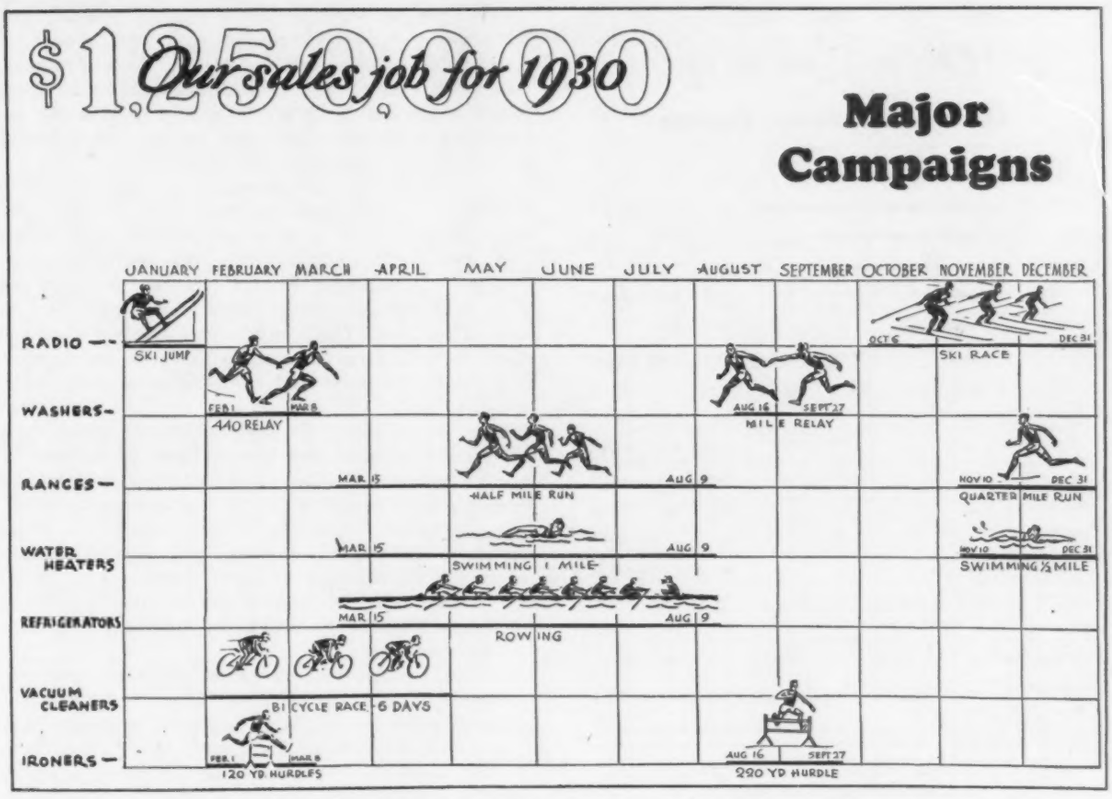
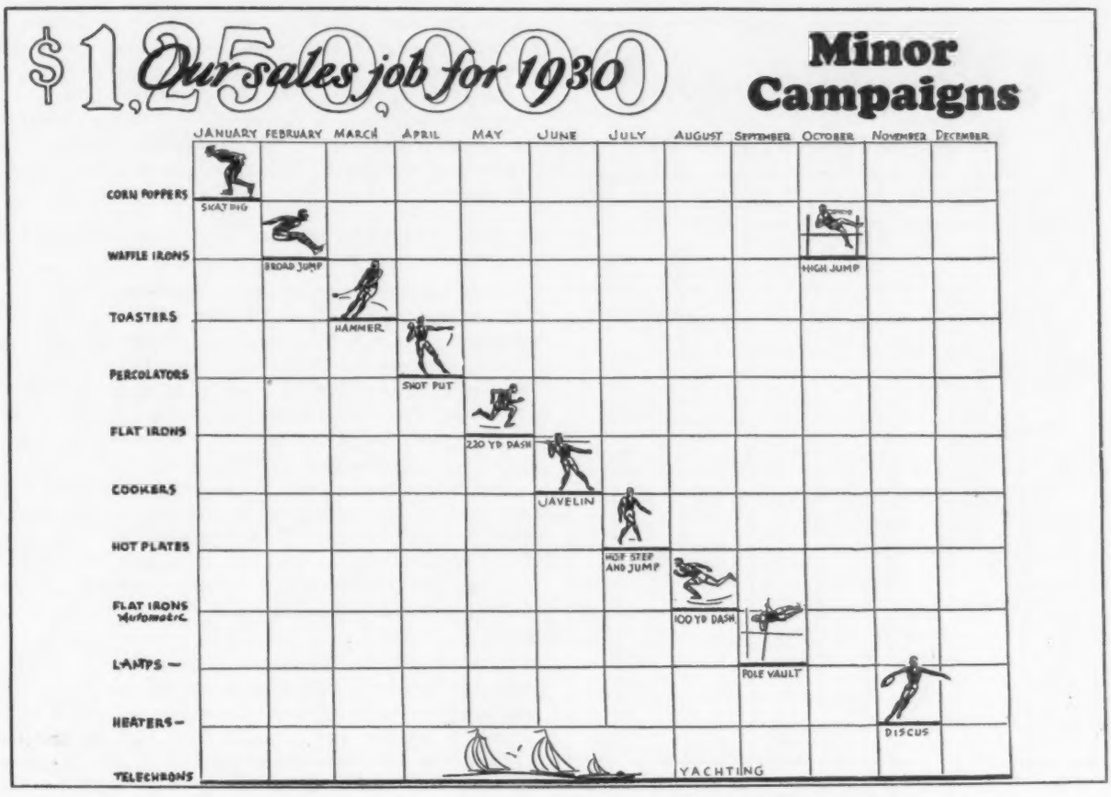
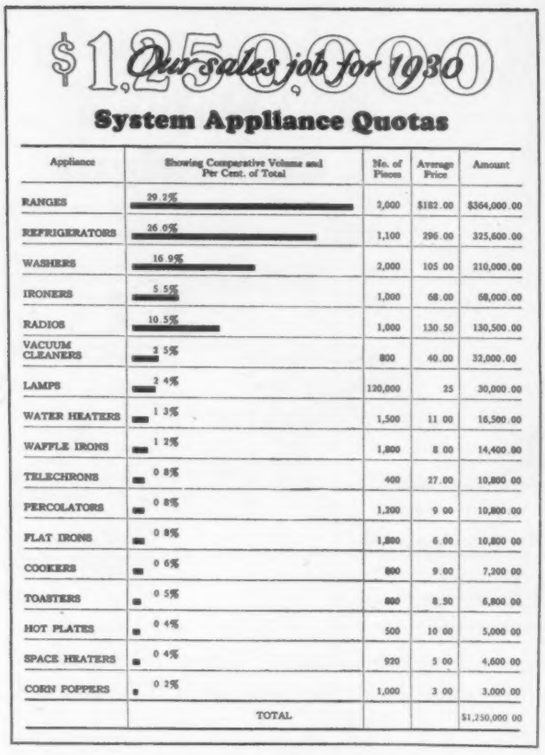


Page 4 of Pacific Power & Light Company's 1930 Merchandising Plan Book



Page 5 of Pacific Power & Light Company's 1930 Merchandising Plan Book



$1,250,000 Our sales job for 1930

System Appliance Quotas

Appliance	Showing Comparative Volume and Per Cent. of Total	No. of Pieces	Average Price	Amount
RANGES	29.2%	2,000	$182.00	$364,000.00
REFRIGERATORS	26.0%	1,100	296.00	325,600.00
WASHERS	16.9%	2,000	105.00	210,000.00
IRONERS	5.5%	1,000	68.00	68,000.00
RADIOS	10.5%	1,000	130.50	130,500.00
VACUUM CLEANERS	2.5%	800	40.00	32,000.00
LAMPS	2.4%	120,000	25	30,000.00
WATER HEATERS	1.3%	1,500	11.00	16,500.00
WAFFLE IRONS	1.2%	1,800	8.00	14,400.00
TELECHRONS	0.8%	400	27.00	10,800.00
PERCOLATORS	0.8%	1,200	9.00	10,800.00
FLAT IRONS	0.8%	1,800	6.00	10,800.00
COOKERS	0.6%	800	9.00	7,200.00
TOASTERS	0.5%	800	8.50	6,800.00
HOT PLATES	0.4%	500	10.00	5,000.00
SPACE HEATERS	0.4%	920	5.00	4,600.00
CORN POPPERS	0.2%	1,000	3.00	3,000.00
	TOTAL			$1,250,000.00

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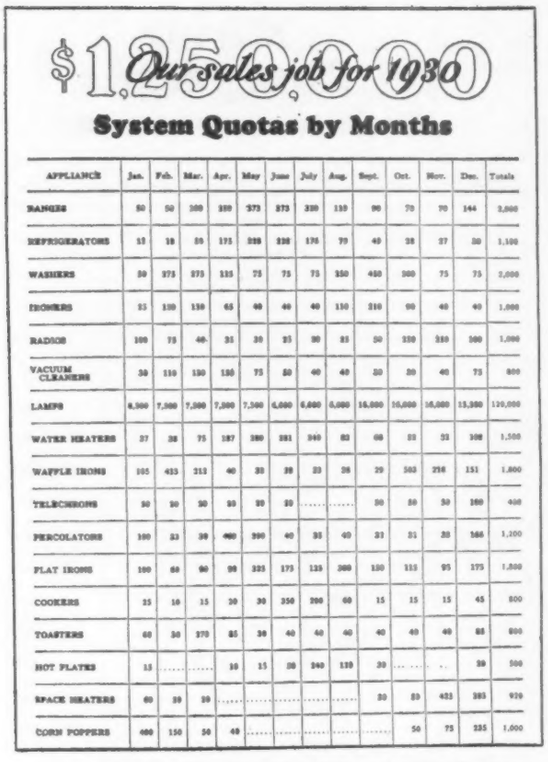

$1,250,000 Our sales job for 1930

System Quotas by Months

APPLIANCE	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Totals
RANGES	50	50	100	100	175	175	100	150	90	70	70	144	2,000
REFRIGERATORS	15	18	55	175	225	225	175	75	40	28	27	30	1,100
WASHERS	50	275	275	125	75	75	75	250	400	200	75	75	2,000
IRONERS	55	100	150	65	60	60	60	150	210	90	60	60	1,000
RADIOS	100	75	60	35	30	25	30	35	50	150	250	100	1,000
VACUUM CLEANERS	30	110	130	130	75	50	60	60	50	30	60	75	800
LAMPS	8,500	7,500	7,500	7,500	7,500	6,000	6,000	6,000	10,000	10,000	10,000	13,500	120,000
WATER HEATERS	37	38	75	187	250	225	200	62	68	53	53	102	1,500
WAFFLE IRONS	105	425	212	60	30	30	30	30	20	502	256	151	1,800
TELECHRONS	50	50	50	50	50	50	.....	.....	50	50	50	100	400
PERCOLATORS	100	53	50	400	200	60	50	60	53	51	50	166	1,200
FLAT IRONS	100	50	90	90	225	175	125	200	150	115	95	175	1,800
COOKERS	25	10	15	50	50	250	200	60	15	15	15	45	800
TOASTERS	60	50	270	85	50	60	60	60	60	60	60	85	800
HOT PLATES	15	.....	.....	10	15	50	240	120	50	.....	..	50	500
SPACE HEATERS	60	50	50	.....	.....	.....	.....	.....	50	50	425	385	920
CORN POPPERS	400	150	50	40	.....	.....	.....	.....	.....	50	75	235	1,000

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It is strongly urged that each member company produce, prior to the beginning of each year, a plan of activity for a twelve-months' period. This is mechanical, to be sure. However, when presented to the direct selling organization, it is the means of creating the necessary perspective, pointing out to each salesman his job in attaining the required result.

Some method of co-ordinating the sales plans of adjoining member companies has been recommended as being important. It is suggested that sales executives meet for this purpose before the beginning of the new year in sufficient time to complete the plan and fit it into the individual company program for the year. This should result in concurrent advertising and eliminate differences in offering the same merchandise to the same customer from two sources at a variation in price.

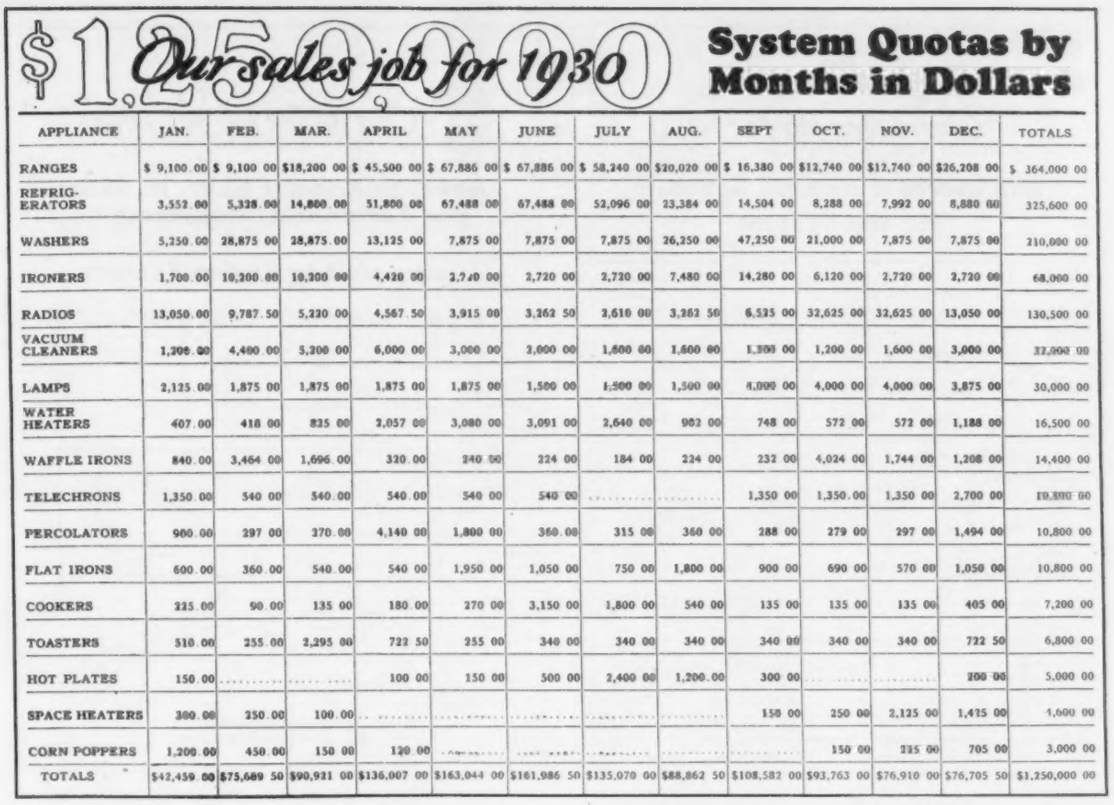
From the results of the committee's questionnaire, it is evident that sales executives of some of the smaller member companies either have not found it necessary or do not have the facilities for preparing a merchandising program. A meeting of sales executives would provide a school for these men and, certainly, would react to the advantage of those companies which do have a sales plan by making possible the larger and more expansive application of merchandising programs for the Northwest.

Another problem which requires somewhat closer coordination is that of quoting the sales price. It is evident and perhaps necessary that each company have a method of announcing installment sales. Therefore, it would seem of considerable value for companies to quote cash prices and have all merchandise priced uniformly with the cash price. Since most standard merchandise is sold at a uniform cash price, it is suggested, in the preparation of advertising, that the cash price appear at least somewhere in the copy if any price is displayed. If member companies that produce a merchandising plan would present it to dealers so that they might tie-in with the program, the initial move on the part of the utility certainly would be evidence of fair play. Manufacturers of merchandise can go a long way in supporting this sort of program by assisting utilities in formulating merchandising plans and submitting the same type of plan to other dealers.

3. Some Essential Factors With Reference to the Merchandise Itself

Clothing manufacturers have succeeded well in placing before their market the slogan "Dress well and succeed." Dressing well does not contemplate wearing lavish garments, but certainly does mean wearing those that are clean, neat, well fitting, and substantial. Of course, it does not follow that all people that dress well succeed; but it is generally true that people that play a successful part in their community life, are reasonably well dressed. It appears, therefore, that the store in the community, if well dressed, represents some degree of success in the community. The store front of the utility is indeed its face and may appear smiling, open and friendly; or mean, crowded and unfriendly in just the degree to which attention is given it.

It is possible in the larger communities to provide good store fronts, well dressed, where the larger organizations have employees whose specific duty it is to attend to window and store displays. In the smaller communities this duty is delegated to some employee as part time work, necessitating some training for these individuals. A few member companies have win-



$1,250,000 Our sales job for 1930

System Quotas by Months in Dollars

APPLIANCE	JAN.	FEB.	MAR.	APRIL	MAY	JUNE	JULY	AUG.	SEPT	OCT.	NOV.	DEC.	TOTALS
RANGES	$ 9,100 00	$ 9,100 00	$18,200 00	$ 45,500 00	$ 67,886 00	$ 67,886 00	$ 58,240 00	$20,020 00	$ 16,380 00	$12,740 00	$12,740 00	$26,208 00	$ 364,000 00
REFRIG-ERATORS	3,552 00	5,328 00	14,800 00	51,800 00	67,488 00	67,488 00	52,096 00	23,384 00	14,504 00	8,288 00	7,992 00	8,880 00	325,600 00
WASHERS	5,250 00	28,875 00	28,875 00	13,125 00	7,875 00	7,875 00	7,875 00	26,250 00	47,250 00	21,000 00	7,875 00	7,875 00	210,000 00
IRONERS	1,700 00	10,200 00	10,200 00	4,420 00	2,720 00	2,720 00	2,720 00	7,480 00	14,280 00	6,120 00	2,720 00	2,720 00	68,000 00
RADIOS	13,050 00	9,787 50	5,220 00	4,567 50	3,915 00	3,262 50	2,610 00	3,262 50	6,525 00	32,625 00	32,625 00	13,050 00	130,500 00
VACUUM CLEANERS	1,200 00	4,400 00	3,200 00	6,000 00	3,000 00	2,000 00	1,600 00	1,600 00	1,200 00	1,200 00	1,600 00	3,000 00	32,000 00
LAMPS	2,125 00	1,875 00	1,875 00	1,875 00	1,875 00	1,500 00	1,500 00	1,500 00	4,000 00	4,000 00	4,000 00	3,875 00	30,000 00
WATER HEATERS	407 00	418 00	825 00	2,057 00	3,080 00	3,091 00	2,640 00	902 00	748 00	572 00	572 00	1,188 00	16,500 00
WAFFLE IRONS	840 00	3,464 00	1,696 00	320 00	240 00	224 00	184 00	224 00	232 00	4,024 00	1,744 00	1,208 00	14,400 00
TELECHRONS	1,350 00	540 00	540 00	540 00	540 00	540 00	.....	.....	1,350 00	1,350 00	1,350 00	2,700 00	10,800 00
PERCOLATORS	900 00	297 00	270 00	4,140 00	1,800 00	360 00	315 00	360 00	288 00	279 00	297 00	1,494 00	10,800 00
FLAT IRONS	600 00	360 00	540 00	540 00	1,950 00	1,050 00	750 00	1,800 00	900 00	690 00	570 00	1,050 00	10,800 00
COOKERS	225 00	90 00	135 00	180 00	270 00	3,150 00	1,800 00	540 00	135 00	135 00	135 00	405 00	7,200 00
TOASTERS	510 00	255 00	2,295 00	722 50	255 00	340 00	340 00	340 00	340 00	340 00	340 00	722 50	6,800 00
HOT PLATES	150 00	.....	.....	100 00	150 00	500 00	2,400 00	1,200 00	300 00	.....	.....	200 00	5,000 00
SPACE HEATERS	300 00	250 00	100 00	.....	.....	.....	.....	.....	150 00	250 00	2,125 00	1,425 00	4,600 00
CORN POPPERS	1,200 00	450 00	150 00	120 00	.....	.....	.....	.....	.....	150 00	225 00	705 00	3,000 00
TOTALS	$42,459 00	$75,689 50	$90,921 00	$136,007 00	$163,044 00	$161,986 50	$135,070 00	$88,862 50	$108,582 00	$93,763 00	$76,910 00	$76,705 50	$1,250,000 00

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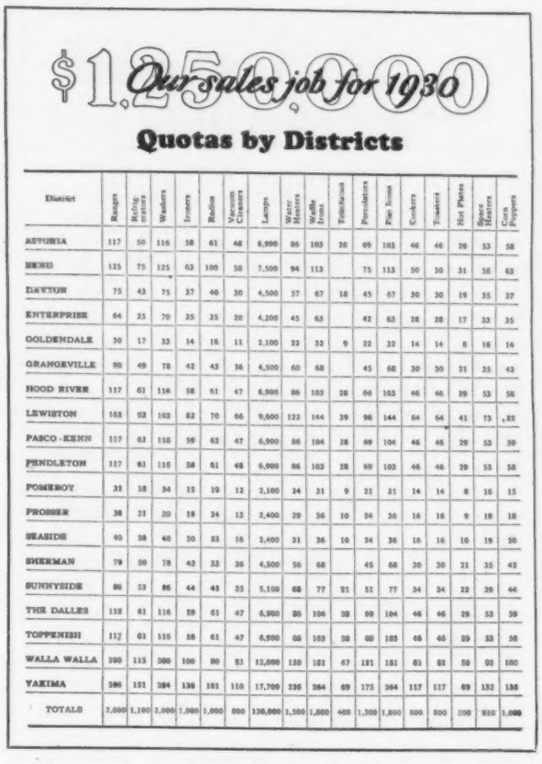

$1,250,000 Our sales job for 1930

Quotas by Districts

District	Ranges	Refrigerators	Washers	Ironers	Radios	Vacuum Cleaners	Lamps	Water Heaters	Waffle Irons	Telechrons	Percolators	Flat Irons	Cookers	Toasters	Hot Plates	Space Heaters	Corn Poppers
ASTORIA	117	50	116	58	61	48	6,900	86	103	28	69	103	46	46	29	53	58
BEND	125	75	125	63	100	50	7,500	94	113		75	113	50	50	31	56	63
DAYTON	75	43	75	37	40	30	4,500	57	67	18	45	67	30	30	19	35	37
ENTERPRISE	64	35	70	35	35	20	4,200	45	63		42	63	28	28	17	33	35
GOLDENDALE	30	17	33	14	16	11	2,100	22	32	9	22	32	14	14	8	16	14
GRANGEVILLE	80	49	78	42	43	36	4,500	60	68		45	68	30	30	21	35	42
HOOD RIVER	117	61	116	58	61	47	6,900	86	103	28	69	103	46	46	29	53	58
LEWISTON	163	93	163	82	70	66	9,600	122	144	39	96	144	64	64	41	73	81
PASCO-KENN	117	63	116	59	62	47	6,900	86	104	28	69	104	46	46	29	53	59
PENDLETON	117	61	116	58	61	48	6,900	86	103	28	69	103	46	46	29	53	58
POMEROY	32	18	34	15	19	12	2,100	24	31	9	21	31	14	14	8	16	15
PROSSER	38	21	20	18	24	13	2,400	29	36	10	24	36	16	16	9	19	18
SEASIDE	40	38	40	20	22	16	2,400	31	36	10	24	36	16	16	10	19	20
SHERMAN	79	30	78	42	32	36	4,500	56	68		45	68	30	30	21	35	42
SUNNYSIDE	86	53	86	44	43	33	5,100	68	77	21	51	77	34	34	22	39	44
THE DALLES	110	61	116	58	61	47	6,900	86	104	28	69	104	46	46	29	53	59
TOPPENISH	117	61	116	58	61	47	6,900	86	103	28	69	103	46	46	29	53	58
WALLA WALLA	200	115	200	100	80	81	12,000	150	181	47	121	181	81	81	50	93	100
YAKIMA	296	151	294	139	101	110	17,700	236	284	69	175	284	117	117	69	132	138
TOTALS	2,000	1,100	2,000	1,000	1,000	800	120,000	1,500	1,800	400	1,200	1,800	800	800	500	900	1,000

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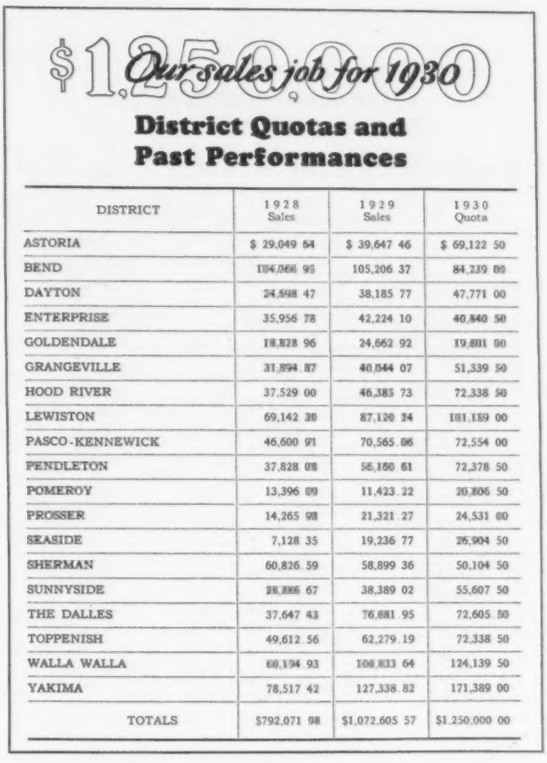

$1,250,000 Our sales job for 1930

District Quotas and Past Performances

DISTRICT	1928 Sales	1929 Sales	1930 Quota
ASTORIA	$ 29,049 64	$ 39,647 46	$ 69,122 50
BEND	104,066 95	105,206 37	84,239 00
DAYTON	24,598 47	38,185 77	47,771 00
ENTERPRISE	35,956 78	42,224 10	40,840 50
GOLDENDALE	18,828 96	24,662 92	19,801 00
GRANGEVILLE	31,894 87	40,044 07	51,339 50
HOOD RIVER	37,529 00	46,385 73	72,338 50
LEWISTON	69,142 30	87,120 24	101,159 00
PASCO-KENNEWICK	46,600 91	70,565 06	72,554 00
PENDLETON	37,828 08	56,160 61	72,378 50
POMEROY	13,396 09	11,423 22	20,806 50
PROSSER	14,265 98	21,321 27	24,531 00
SEASIDE	7,128 35	19,236 77	25,904 50
SHERMAN	60,826 59	58,899 36	50,104 50
SUNNYSIDE	28,886 67	38,389 02	55,607 50
THE DALLES	37,647 43	76,681 95	72,605 50
TOPPENISH	49,612 56	62,279 19	72,338 50
WALLA WALLA	60,194 93	106,833 64	124,139 50
YAKIMA	78,517 42	127,338 82	171,389 00
TOTALS	$792,071 98	$1,072,605 57	$1,250,000 00

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Do

$1,250,000 *Our sales job for 1930*

and Increase Annual Revenue for the System

QUOTA	APPLIANCE	Estimated Annual K. W. H. Consumption	TOTAL K. W. H.	Rate per K. W. H.	ESTIMATED TOTAL ANNUAL REVENUE
2,000	RANGES	1,500	3,000,000	$ 03	$ 90,000 00
1,100	REFRIGERATORS	500	550,000	.04	22,000 00
2,000	WASHERS	24	48,000	05	2,400 00
1,000	IRONERS	125	125,000	05	6,250 00
1,200	RADIOS	150	150,000	05	7,500 00
800	VACUUM CLEANERS	30	24,000	05	1,200 00
120,000	LAMPS				
1,500	WATER HEATERS	3,600	5,400,000	.005	27,000 00
1,800	WAFFLE IRONS	23	41,400	.05	2,070 00
400	TELECHRONS				
1,200	PERCOLATORS	50	60,000	05	3,000 00
1,800	FLAT IRONS	72	129,600	.05	6,480 00
800	COOKERS	111	88,840	.05	4,440 00
800	TOASTERS	50	40,000	.05	2,000 00
500	HOT PLATES	200	100,000	.04	4,000 00
920	SPACE HEATERS	40	36,800	.05	1,840 00
1,000	CORN POPPERS	10	10,000	.05	500 00
		TOTAL	9,803,600	TOTAL	$180,680.00

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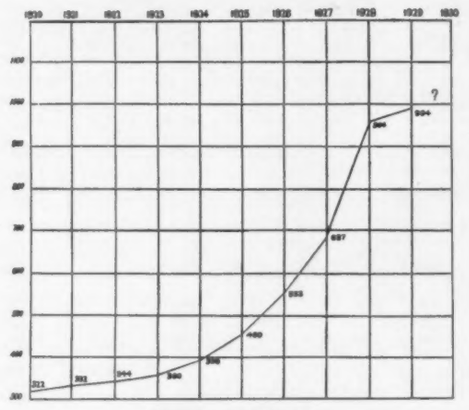
$1,250,000 *Our sales job for 1930*

Average Annual K. W. H. Sales per Residential Customer in

Compared to Entire System



System curve is in black
Your district curve is in red

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$1,250,000 *Our sales job for 1930*

Residential K. W. H. Sales Statistics

DISTRICT	K. W. H. Sales per Residential customer for year ending Oct. 31, 1929	Average Revenue per Residential Customer for year ending Oct. 31, 1929	Water Heaters in use Oct. 31, 1929		Ranges in use Dec. 31, 1929	
			Number	% of Res. Cust.	Number	% of Res. Cust.
ASTORIA	364	$29 46	9	30	150	5 2
BEND	1071	37 98	554	17 37	723	22 7
DAYTON-WAITSBURG	1021	34 60	187	15 02	234	17 9
ENTERPRISE	1385	38 42	165	16 55	180	19 0
GOLDENDALE	710	30 92	38	8 64	81	17 8
GRANGEVILLE	1022	38 13	165	12 56	131	9 6
HOOD RIVER	1578	41 77	262	14 52	368	20 6
LEWISTON	979	36 69	466	11 18	830	19 7
PASCO-KENNEWICK	1201	39 42	296	14 26	464	22 1
PENDLETON	715	30 67	105	4 80	184	8 7
POMEROY	1213	36 43	87	17 19	99	19 9
PROSSER	1259	38 11	103	17 63	136	22 2
SEASIDE	349	29 84	7	66	58	6 6
SHERMAN	972	41 66	133	10 82	184	15 1
SUNNYSIDE	994	37 41	187	11 71	333	20 7
THE DALLES	1616	39 89	419	20 87	563	28 8
TOPPENISH	1201	39 33	245	11 78	418	19 8
WALLA WALLA	643	30 10	230	4 30	529	10 0
WHITE SALMON	1216	38 18	57	15 32	78	20 9
YAKIMA	794	32 93	774	8 23	1142	21 1
AVERAGE	994	$35 00	4488	10 09	6875	15 5

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GRANGEVILLE-CRIPPEN **District**

$1,250,000 *Your sales job for 1930*

APPLIANCE	No. of Pieces	Average Price	TOTAL
Ranges	80	$182.00	$ 14,560 00
Refrigerators	49	296.00	14,504 00
Washers	78	105.00	8,190 00
Ironers	42	68.00	2,856 00
Radios	43	130.50	5,611 50
Vacuum Cleaners	36	40.00	1,440 00
Lamps	4500	.25	1,125 00
Water Heaters	60	11.00	660 00
Waffle Irons	68	8.00	544 00
Telechrons	-	27.00	- -
Percolators	45	9.00	405 00
Flat Irons	68	6.00	408 00
Cookers	30	9.00	270 00
Toasters	30	8.50	255 00
Hot Plates	21	10.00	210 00
Space Heaters	35	5.00	175 00
Corn Poppers	42	3.00	126 00
		Total	$ 51,339 50

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Do

$1,250,000 Your sales job for 1930

and Increase

Annual Revenue in GRANGEVILLE-GRIFINO District

Number of Quota	APPLIANCE	Estimated Annual K.W.H. Consumption	Estimated Total Annual K. W. H. Consumption	Rate per K.W.Hr.	ESTIMATED ANNUAL REVENUE
80	Ranges	1500	120,000	$ .03	$ 3,600.00
49	Refrigerators	500	24,500	.04	980.00
78	Washers	24	1,872	.05	93.60
42	Ironers	125	5,250	.05	262.50
43	Radios	150	6,450	.05	322.50
36	Vacuum Cleaners	30	1,080	.05	54.00
82	Water Heaters	3600	216,000	.005	1,080.00
4500	Lamps				
-	Telechrons				
68	Waffle Irons	23	1,564	.05	78.20
45	Percolators	50	2,250	.05	112.50
30	Cookers	111	3,330	.05	166.50
68	Flat Irons	72	4,896	.05	244.80
30	Toasters	50	1,500	.05	75.00
35	Space Heaters	40	1,400	.05	70.00
42	Corn Poppers	10	420	.05	21.00
21	Hot Plates	200	4,200	.04	168.00
	TOTAL		394,712	TOTAL	$ 7,328.60

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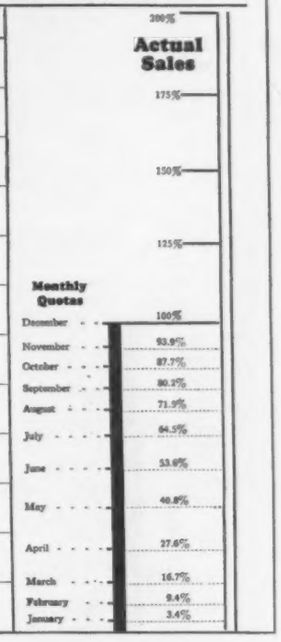
$1,250,000 Your sales job for 1930

GRANGEVILLE-GRIFINO **Salesometer**

To End of	QUOTA	SALES
January	$ 1,484.00	1,675.53
February 2 months	2,984.00 4,468.00	4,129.89
March 3 months	3,925.00 8,393.00	
April 4 months	5,832.50 14,225.50	
May 5 months	6,745.00 20,970.50	
June 6 months	6,810.75 27,781.25	
July 7 months	5,527.75 33,309.00	
August 8 months	3,568.25 36,877.25	
September 9 months	4,402.00 41,279.25	
October 10 months	4,048.00 45,327.25	
November 11 months	3,080.50 48,407.75	
December 12 months	2,931.75 51,339.50	



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$1,250,000 Your sales job for 1930

GRANGEVILLE-GRIFINO DISTRICT

Quotas and Sales by Months

		Jan.	Feb.	2 Mo. Total	Mar.	3 Mo. Total	April	4 Mo. Total	May	5 Mo. Total	June	6 Mo. Total	July	7 Mo. Total	Aug.	8 Mo. Total	Sept.	9 Mo. Total	Oct.	10 Mo. Total	Nov.	11 Mo. Total	Dec.	GRAND TOTAL
REFRIGERATORS	Quota	-	1	1	2	3	8	11	10	21	10	31	8	39	4	43	2	45	2	47	1	48	1	49
	Sales																							
RANGES	Quota	2	2	4	5	9	10	19	15	34	15	49	12	61	4	65	3	68	3	71	3	74	6	80
	Sales																							
WASHING MACHINES	Quota	2	10	12	11	23	5	28	3	31	3	34	3	37	8	45	19	64	8	72	3	75	3	78
	Sales																							
IRONERS	Quota	1	6	7	7	14	3	17	1	18	2	20	1	21	5	26	10	36	3	39	1	40	2	42
	Sales																							
RADIOS	Quota	4	3	7	2	9	2	11	1	12	1	13	1	14	1	15	2	17	11	28	11	39	4	43
	Sales																							
VACUUM CLEANERS	Quota	1	5	6	6	12	7	19	4	23	3	26	2	28	2	30	1	31	1	32	1	33	3	36
	Sales																							
LAMPS	Quota	320	280	600	280	880	280	1160	280	1440	225	1665	225	1890	225	2115	600	2715	600	3315	600	3915	585	4500
	Sales																							
WATER HEATERS	Quota	1	1	2	3	5	7	12	12	24	12	36	9	45	3	48	4	52	2	54	2	56	4	60
	Sales																							
WAFFLE IRONS	Quota	4	17	21	7	28	2	30	1	31	1	32	1	33	2	35	1	36	19	55	8	63	5	68
	Sales																							
TELECHRONS	Quota	NONE																						
	Sales																							
PERCOLATORS	Quota	4	1	5	1	6	17	23	8	31	2	33	1	34	2	36	1	37	1	38	1	39	6	45
	Sales																							
FLAT IRONS	Quota	4	2	6	3	9	3	12	12	24	7	31	5	36	11	47	6	53	4	57	4	61	7	68
	Sales																							
COOKERS	Quota	1	-	1	1	2	1	3	1	4	14	18	7	25	2	27	1	28	1	29	-	29	1	30
	Sales																							
TOASTERS	Quota	2	1	3	10	13	3	16	1	17	2	19	2	21	1	22	2	24	1	25	2	27	3	30
	Sales																							
HOT PLATES	Quota	1	-	1	-	1	-	1	1	2	2	4	10	14	5	19	1	20	-	20	-	20	1	21
	Sales																							
SPACE HEATERS	Quota	2	2	4	1	5	-	5	-	5	-	5	-	5	-	5	1	6	2	8	17	25	10	35
	Sales																							
CORN POPPERS	Quota	17	6	23	2	25	2	27	-	27	-	27	-	27	-	27	-	27	2	29	3	32	10	42
	Sales																							

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$1,250,000 Your sales job for 1930

GRANGEVILLE-ORIFINO DISTRICT

Monthly Standings for President's Balanced Sale Prize

QUOTA	APPLIANCE	Points for Quota	Points made to Jan. 26	Points made to Feb. 26	Points made to Mar. 26	Points made to Apr. 26	Points made to May 26	Points made to June 26	Points made to July 26	Points made to Aug. 26	Points made to Sept. 26	Points made to Oct. 26	Points made to Nov. 26	Total Points for Year
80	RANGES	1000												
49	REFRIGERATORS	1000												
78	WASHERS	400												
42	IRONERS	400												
43	RADIOS	400												
36	VACUUM CLEANERS	200												
4500	LAMPS	200												
60	WATER HEATERS	500												
68	WAFFLE IRONS	100												
-	TELECHRONS	100												
45	PERCOLATORS	120												
68	FLAT IRONS	140												
30	COOKERS	160												
30	TOASTERS	110												
21	HOT PLATES	160												
~~33~~	SPACE HEATERS	80												
42	CORN POPPERS	50												
	Total	5120												

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$1,250,000 Your sales job for 1930

GRANGEVILLE ORIFINO **Sales Picture for** MARCH

APPLIANCE	QUOTA		SALES		+			
Ranges	$ 910	00						
Refrigerators	592	00						
Washers	1,155	00						
Ironers	476	00						
Radios	261	00						
Vacuum Cleaners	240	00						
Lamps	70	00						
Water Heaters	33	00						
Waffle Irons	56	00						
Telechrons								
Percolators	9	00						
Flat Irons	18	00						
Cookers	9	00						
Toasters	85	00						
Hot Plates								
Space Heaters	5	00						
Corn Poppers	6	00						
Miscellaneous								
TOTAL	$ 3,925	00						

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dow displays prepared by experts and photographs of these displays sent to outlying districts for guidance. This is an expensive process if the displays are not used effectively, but serves the purpose if used properly.

Since the appearance of the utility is at stake just as much in the smaller community as in the larger community, and perhaps to a larger degree, it is urged that more attention be given to window displays in the smaller community. A good store display not only serves to present merchandise effectively but indicates to the customer that the utility has a businesslike interest in merchandising and should leave the impression that the utility backs up its sales with comparable service.

Demonstration of appliances should tie in with the advertising program so that the customer may have some knowledge, before coming to the store, that such an appliance is on sale. It is necessary, therefore, to have demonstrations located in the most accessible place so the customer will find it convenient and interesting to stop and get the entire story. Demonstrations should be located and so arranged that they will provide an interesting picture to the casual observer. The personality and the sales methods used by the demonstrator are of considerable importance and, wherever possible, the demonstrator should permit the prospective customer to demonstrate to himself and perhaps visualize himself using the article in his own home.

The committee has given some thought to standardization of models. Most member companies have adopted standard merchandise and carry, principally, one or two lines. Benefits in having few models of any particular appliance are: a smaller stock; elimination, to some

extent, of obsolescence; and concentration of effort in the actual sale of the appliance. There, of course, are situations with respect to the larger appliances in which the sale is predicated upon space. It is necessary, therefore, to have different sizes. But in some instances, it has been found that the customer still has a choice between several models of the same size. The manufacturer can aid materially in standardizing models and sizes, and the utility also can assist by preparing a program based upon the sale of standard sizes and models. The mechanical structure of appliances also should be so standardized that replacements can be made easily and from the utility's parts stock. Standardization here means much in service to the customer. If appliances have odd parts requiring delivery from factory, service to the customer is greatly impaired and the cost to the utility is considerably increased.

4. The Problem of Employee Participation in the Merchandising Activity

This is a subject which was discussed as part of last year's report, and actual results obtained by several member companies are evidence that some good has been accomplished. Several plans to enlist the support of employees in the merchandising program have been tried. In some of the smaller communities where full time salesmen are not employed, it has been necessary to solicit participation of operating employees. Here it is easy to appeal to the personal interest of the employee because he gets full credit and recognition for his efforts. In the larger organizations, the sales job represents, in general, the efficiency of the sales department. Since the sales department obtains credit for the result, it is its obligation in some way to solicit personally the interest of employees. Every employee will participate in the program in some degree if his immediate superior shows interest in it and, here again, may be seen the importance of executive interest in the merchandising plan. It is well to provide special employee commissions for individual sales resulting from prospects which have been turned in to the sales department, but this plan can have little effect if it is not personally followed through by an individual of the sales department.

It is suggested that every employee be assigned to some salesman whose duty it is to sell the employee on the sales plan. This should produce sales for salesmen and commissions for employees, both of which are de-

PORTLAND ELECTRIC POWER COMPANY
GENERAL OFFICES
ELECTRIC BUILDING

January 2, 1930

320 ALDER STREET
PORTLAND, OREGON

To Company Employees:

During the year 1929 a new plan for our merchandising activities was set up and tried out. Our experience with it prompts us to continue along similar lines this year. This booklet has been pr pared for the purpose of outlining to you our aims and ambitions for the year 1930. A series of sales campaigns, as you will note, forms the basis of the year's work. Much care and attention has been given to working up the information set forth, and it is hoped it will prove to be of assistance to you.

Only by each and every employee knowing and intelligently carrying out the part assigned to him or her and cooperating as a unit in our organization can we expect to achieve the goal set. The success of our merchandising efforts in 1930 and the increase in kilowatt hours resulting therefrom will automatically help take up any slack there might be, due to decrease in the building program. Therefore it is particularly important that we all put in our best endeavors in making this year's work a success.

I expect your hearty support.

O. B. Coldwell.

Vice President

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PORTLAND ELECTRIC POWER COMPANY
ELECTRIC BUILDING

FRANKLIN T. GRIFFITH
PRESIDENT

PORTLAND, OREGON
January 9, 1930.

Mr. A. C. McMicken,
General Sales Manager,
Building.

Dear Mr. McMicken:

The plan to increase our merchandising activities during this year without materially increasing our selling organization appeals to me because, if the quotas established are to be reached, employes in all departments will have to assist those actively engaged in merchandising by developing live prospects for our selling organization. This should be done as a part of their work in their daily contacts with our customers, their friends and acquaintances.

The use of electricity in the home is developing steadily to the mutual benefit of our company and its customers. This increased use is largely brought about by the more general use of all manner of labor-saving devices from electric ranges to the smaller lamp-socket devices.

I shall watch the progress of these campaigns with interest and sincerely hope that at the end of the year I will find that more than $700,000 of merchandise has been sold.

Yours very truly,

Franklin T. Griffith

President.

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PORTLAND ELECTRIC POWER COMPANY
GENERAL OFFICES
ELECTRIC BUILDING

January 2, 1930

320 ALDER STREET
PORTLAND, OREGON

Members of the Pepco Family.

Dear Friends:

Increasing residential revenues by selling all manner of labor-saving electrical appliances is a major commercial activity and not merely incidental to the conduct of our business. Although the average number of kilowatt hours used annually by our residential customers is now high, a very large percentage of these customers have not yet been made to realize that electrical servants are the cheapest and most efficient that can be employed.

This is a task in which every employe, and not merely the members of our Commercial organization, can and should take part. In selling the idea of the use of labor-saving electrical appliances to our customers, we are doing them a real favor and can take pride in every sale made.

Our 1930 merchandise sales bogey of $700,000, while appreciably greater than our gross sales for 1929, can and will be reached by hard work and the same fine spirit of cooperation by employes in all departments which has existed during the past year. Definite quotas for both major and minor selling campaigns are set forth herein for each month of 1930. Make good on each monthly quota, and the annual quotas will take care of themselves.

Remember that in securing prospects or in making sales you are an integral part of an organization which for more than forty years has rendered an essential service to the public and has established an enviable reputation for fair and honorable dealing with its customers.

Our newly installed "Home Service" representative plan will give introduction to and insure regular contact with our customers, which will not only make it easier to make sales, but will also provide the opportunity to better public relations.

Our bogey of $700,000 of merchandise during 1930, with more than 63,000 residential customers for prospects, will be a comparatively easy task, if all employes will help by sending in the names of prospects and by talking up the smallest-salaried "hired girl" known to history--ELECTRICITY.

Yours for $700,000

A. C. McMicken

General Sales Manager.

Page 3 of the sales Plan Book of the Pacific Northwest Public Service Company

PORTLAND ELECTRIC POWER COMPANY
GENERAL OFFICES
ELECTRIC BUILDING

326 ALDER STREET
PORTLAND, OREGON

Jan. 10, 1930

Members of the Pepco Family:

We have set forth a definite sales goal of $700,000 for 1930.

We have assigned to each district what we believe to be a fair, reasonable and obtainable quota. The yearly plan has been separated into appliance sales by months, so that you can readily check your progress.

Your fine cooperation and splendid record in many of the campaigns of 1929 enabled us to close the best merchandising year in our history, but we have only started.

With our KARDEX system installed, definite major and minor campaigns outlined for each month, more attractive merchandise available than ever before, a strong and efficient advertising program supporting you, I feel sure that you will put the ball behind the goal.

Yours very truly,

G. A. KUMLER,
Merchandise Manager

GAK:G

Page 4 of the sales Plan Book of the Pacific Northwest Public Service Company

sirable. Employees should be kept thoroughly informed of the progress of the merchandising plan and thereby maintain an active interest. One company requires that a salesman call at the home of an employee after working hours and explain the plan to his entire family. Any prospects which have been turned in by an employee or his family are acknowledged personally by the salesman.

Participation by any employee in the merchandising program improves the utility public relations for the reason that, if the employee attempts to make sales to any of his friends, he presents the company in its best light. The employee improves himself by learning salesmanship and, in the end, becomes a very intelligent representative of the company. This committee recommends an organized plan of employee participation for each member company.

5. The Training of Salesmen for Public Utility Merchandising

This subject is more important than any other subject the committee has undertaken to study. Too often a salesman is employed without much thought having been given to his capability. He is sent out the front door with a lot of mechanical data in hand, a list of prospects, and a word of encouragement from his superior to "bring in the bacon." The minute he leaves the front door he becomes a representative of the company. First of all, therefore, a salesman should know thoroughly the general policies of the company—not merely know of the merchandise he is to sell. Many times it is necessary for him to interpret company policy, and his ability to know his employer's business many times is a determining factor in his ability to gain the confidence of the prospective purchaser.

There are certain general steps in the sale of an appliance to the prospective customer and, if un-

YOUR JOB

for

1930

Portland Electric Power Co.

Electric Store-Electric Bldg. *Elder near Broadway-Portland, Oregon*

Portland, Gresham, Oregon City, Salem

St. Johns, St. Helens, Hillsboro and Vancouver, Wash.

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THE GOAL

$700,000

in Merchandise Sales

for

1930

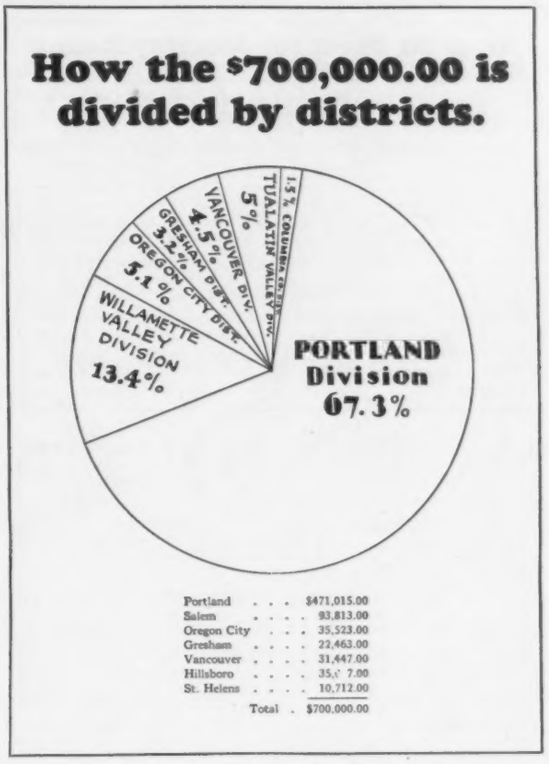
Page 6 of the sales Plan Book of the Pacific Northwest Public Service Company

trained, the salesman is very likely to attempt to create a desire in the customer's mind even before he has informed the customer as to the application of the appliance, or has aroused any interest in it. This and many other similar examples are evidence of improper preliminary training. People in general buy for one of seven reasons, as outlined by one authority: profit, pride, pleasure, caution, utility, love and ambition. Unless the salesman is trained to observe the reason the prospective purchaser is interested in the appliance, he has not placed himself in proper position to make the sale.

As a protection against this fault of organization, this committee suggests that more instruction be given from time to time by sales supervisors along the line of sales methods and analyses of the problems to be met in personal contact with prospective customers. It also is a wise plan to use older and more experienced salesmen as teachers of new and younger men. Frequently it is necessary also for the sales supervisor or "Big Brother" to go with his salesman from time to time to observe exactly how sales are being conducted.

Much time has been given to production of salesmen's manuals, which prescribe all of the mechanical details involved in merchandising and also in setting up the mechanical program, specifying sales prices, schedules of advertising, and other "mechanics." These are essential tools for the salesman to work with, and several member companies have done fine work with them.

Comparatively little, however, has been done about the "humanics" of selling. The personality of the utility is the composite of the personality of its individual employees. Salesmen perhaps are more frequently on the premises of the customers than any other class of employees. How important it is that they present a pleasing personality! It is necessary indeed that they have a pleasant approach with a cheerful "good morning" or a


How the $700,000.00 is divided by districts.
PORTLAND Division 67.3%
WILLAMETTE VALLEY DIVISION 13.4%
OREGON CITY DIST. 3.1%
GRESHAM DIST. 3.2%
VANCOUVER DIV. 4.5%
TUALATIN VALLEY DIV. 5%
1.5% CORNELIUS DIST.
Portland . . . $471,015.00
Salem 93,813.00
Oregon City . . . 35,523.00
Gresham 22,463.00
Vancouver 31,447.00
Hillsboro . . . . 35,5[illegible] 7.00
St. Helens 10,712.00
Total . $700,000.00

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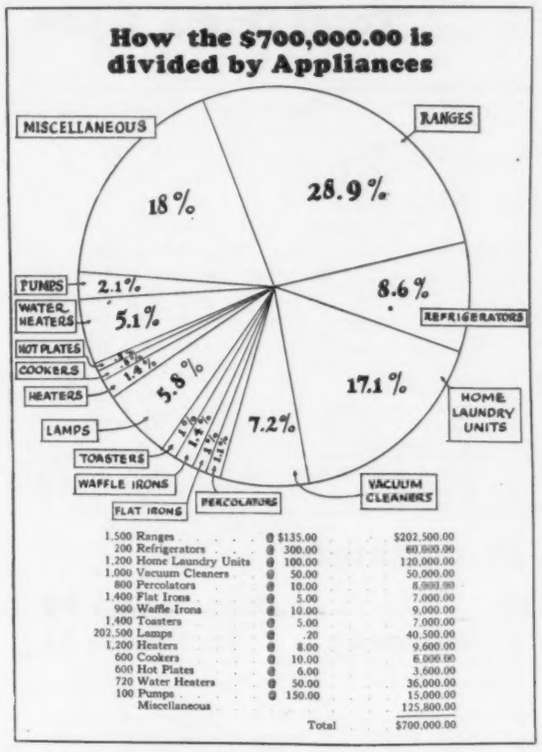

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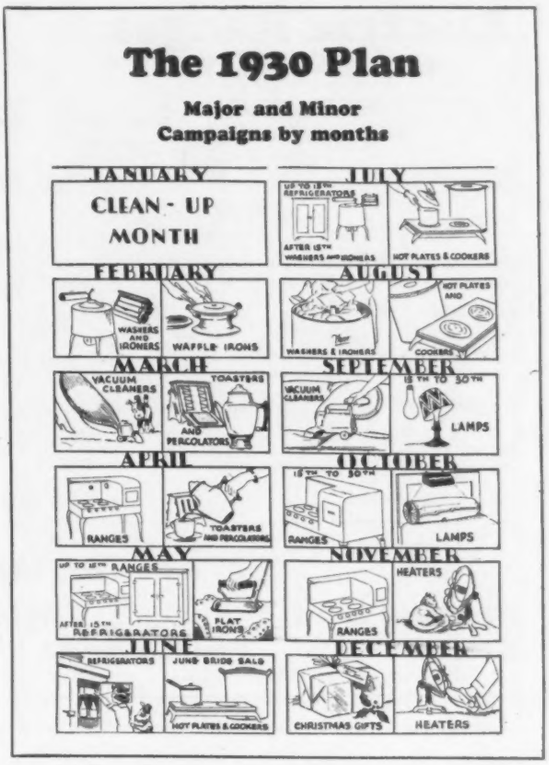

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Progress Sheet for Monthly Record

		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
RANGES	Quota												
	Sales												
REFRIGERATORS	Quota												
	Sales												
HOME LAUNDRY UNITS (Washers and Ironers)	Quota												
	Sales												
VACUUM CLEANERS	Quota												
	Sales												
PERCOLATORS	Quota												
	Sales												
FLAT IRONS	Quota												
	Sales												
WAFFLE IRONS	Quota												
	Sales												
TOASTERS	Quota												
	Sales												
LAMPS	Quota												
	Sales												
HEATERS	Quota												
	Sales												
COOKERS	Quota												
	Sales												
HOT PLATES	Quota												
	Sales												
WATER HEATERS	Quota												
	Sales												
PUMPS	Sales												
MISCELLANEOUS	Sales												
TOTALS													

Page 10 of the sales Plan Book of the Pacific Northwest Public Service Company

kindly salutation over the telephone. How do you, personally, like to be treated when you go into a store to purchase a necktie? First of all, we are sure you like to be greeted by name, if possible, or at least cheerfully. You like to feel, also, that your business is considered very valuable however small your purchase may be. If you have some question as to the store's policy, we are sure you like to have it explained somewhat in detail and with a feeling that it was not too much for you to ask. You like to do business in the store where there seems to be some distinct personality. We think you will agree that this would be an asset to any public utility business.

We have a right to expect that the mental attitude of the salesman be right. That is, that his outlook on life be broad enough to make an intelligent association with many types of people; that he have the right viewpoint of his job; and that he have some loyalty to the company he represents. We too often forget that a salesman's health habits are a determining factor in his work. We sometimes say that he is employed only for eight hours a day, yet his activities in the community outside of business hours very often have a direct reflection on his sales. Frequently, the company is judged by his actions while off regular duty. Indeed, if we have a choice in selecting salesmen, we surely expect to select men who will represent the company well at all times.

Summary

In order, therefore, that we may draw some definite conclusion from the report just presented, this committee recommends the following:

SALES QUOTAS BY APPLIANCES

Electric Ranges — Total Quota 1,500

	JAN	FEB.	MAR.	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
PORTLAND	36	61	70	155	154	45	73	77	70	155	154	35
SALEM	4	14	15	25	24	6	8	9	7	25	24	5
OREGON CITY	1	4	4	11	11	2	3	3	3	11	11	2
GRESHAM	1	4	4	8	8	1	1	1	1	8	8	2
VANCOUVER	1	4	4	8	8	1	2	3	2	8	8	2
HILLSBORO	1	4	4	11	11	1	2	3	2	11	11	2
ST HELENS	1	2	2	3	3	1	1	1	1	3	3	1
TOTALS PER MONTH	45	93	103	221	219	57	90	97	86	221	219	49

TOTALS FOR 1930 BY DISTRICTS

Portland 1,085 **Salem 166** **Oregon City 66**
Gresham 47 **Vancouver 51** **Hillsboro 63** **St. Helens 22**

Page 11 of the sales Plan Book of the Pacific Northwest Public Service Company. This page is typical of twelve other pages each of which gives similar information concerning other major items including refrigerators, home laundry units, vacuum cleaners, percolators, flat irons, waffle irons, toasters, lamps, heaters, cookers, hot plates, and water heaters

1. That every merchandising unit of the association have a concrete plan containing all of the essential elements to make it properly balanced.

2. That more particular attention be given the problem of salesmen training with special emphasis upon "humanics" rather than "mechanics."

In addition to the above, it is recommended that the association continue to encourage a keen interest in commercial activities from operating executives; that some attention be given to the window displays of merchandise and to the standardization of sizes and models of merchandise; and that each member company systematically organize the efforts of operating employees towards participation in sales activities.

POWER BUREAU[2]

*Commercial Cooking and Baking**

IN LAST year's report the committee showed the potential market for heavy duty cooking and baking equipment. In this year's report we shall attempt to show some of the many questions met with in procuring this type of load.

It is an apparent fact that there is a wide field open to the central station that at present is not actively seeking this admittedly desirable load. Desirable because it produces substantial additional revenue at the average rate of $24 per kw. connected per year in this geographic section where there is a saturation in commercial cooking of less than 2 per cent.

Commercial Cooking

Initial Cost—Initial cost of heavy-duty electric cooking equipment is approximately three times that of equipment using other types of fuel.

In installations of $1,000 or more this cost is not a serious obstacle if the financing plan of the company or the kitchen supply house is such that the account can be carried over a reasonable length of time at a moderate carrying charge.

Replacement of Used Equipment—Attempts to replace other types of fuel equipment as yet have met with little success. This is due in large part to the fact that no adequate plan for the disposal of used equipment of other types has been worked out. "Trade-ins" are not desirable from the central station standpoint and few concerns will install new equipment without some allowance for the old.

No strictly ethical solution has been advanced to cope with the "trade-in" situation other than direct "trade-in allowance" as has been practiced in the past. It is the opinion of the committee that this particular phase of this grave problem demands co-ordinated and careful consideration to the end that we receive our rightful share of this replacement business.

Wiring Costs—Wiring costs, in some instances and under certain conditions, form a serious problem. An instance to illustrate this point is reported by one central station:

A customer, with whom the local gas company had been working, was sold electric equipment. The gas company had run 260 ft. of 2-in. pipe, without cost to the owner, to reach the kitchen. When electric equipment was ordered, the cheapest bid obtainable for wiring was $350. Adding this to the price of the equipment, the total cost of the electric installation was $1,829 against a total of $495 for gas installation.

Baking Load

Baking load is in much better condition, as far as electric installations are concerned, than the cooking load. The saturation has reached approximately 30 per cent. The initial cost of small ovens is on a parity with ovens using other fuels. Large ovens, especially the traveling type, in many cases are lower in price than the same type of oven using other fuels.

Competition—Manufacturers of competitive types of fuel ovens have come to the realization that the electric oven is a real factor in the baking industry. Keener competition may be expected in the future from these sources. This will be especially noticeable from gas- and oil-fired types.

Also it is rumored that the manufacturers of oil-fired ovens and some of the large distributors of fuel oil are lining up a campaign for this year for a concentrated effort on bakers. We have an accurate report of one bakery using a traveling tray-type oven, oil fired, in which bread is being baked for a fuel cost of 50 cents per 1,000 lb.

One gas company is making bids for this business guaranteeing the full cost won't exceed 80 cents per 1,000 lb., and from its rates it appears that it is perfectly safe in quoting this figure with the probability of cutting it at least 10 per cent on any job with large production.

Competitive Advertising—The Pacific Coast Gas Association has instituted an advertising campaign which has been well under way for the past year. A determined drive is being made by that association in conjunction with one of the large manufacturers of gas-fired traveling ovens to secure any traveling oven business which may develop. A determined attempt also is being made by certain manufacturers of competitive types of fuel ovens to replace electric ovens with those of their own manufacture.

While these efforts have been successful only in a few isolated cases, these instances have been broadcast by advertising of a rather unethical nature.

Investigation of several of these cases reveals the fact that while the figures quoted are correct, they are presented in a misleading manner. In one instance the electric oven was replaced by a wood-fired oven of much smaller capacity and the shop had *reduced* its production more than 50 per cent.

In another instance an electric oven was located in a community where a 4-cent electric rate was in effect for this type of load. Later oil was struck in the vicinity and the natural consequence was that cheap oil replaced the electricity as fuel.

In none of this type of advertising is any reference made to electric rates, the total bill being the only thing mentioned and this only in cases of extreme differences.

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[2] J. D. Scott, Pacific Northwest Public Service Company, chairman.

* Report of the commercial cooking and baking committee. A. B. Chambers, Pacific Northwest Public Service Company, chairman.

Edison General Electric Appliance Company: C. J. Anderson.

Puget Sound Power & Light Company: William Clancey.

Rainier Electric Oven & Equipment Company: T. C. Reichardt.

Utah Power & Light Company: G. P. Traynor.

The Washington Water Power Company: Carl Hoffman.

Westinghouse Electric & Manufacturing Company: C. L. Weaver.

We have yet to find a case mentioned in any locality where fuel costs are comparable with electric rates.

We do not wish to stress this point too strongly, but it must be conceded that if this advertising is continued without any attention on the part of the electrical industry, in time it will have a demoralizing effect on this type of business.

Summary and Conclusions

From the study we have made, our conclusions and suggestions are as follows:

1. Prices of heavy-duty cooking equipment should be lowered to attract this type of load.
2. Concessions from the merchandising profit should be made where necessary to cover high wiring costs or trade-ins on used equipment.
3. Adequate financing of installations should be offered.
4. Rates that will attract this type of load should be put into effect.
5. An advertising program by the association similar to that used by the Pacific Coast Gas Association should be worked out in the trade journals in this territory.
6. Continual contact should be made with customers using electric equipment to offset competitive propaganda issued. (One central station reports that favorable results have been obtained through monthly visits by its specialists to each commercial fuel prospect.)
7. Continual education of customers and prospects in the advantages and savings of electric cooking and baking and the economical use of them should be undertaken.
8. Close co-operation between central station specialists in the exchange of data and ideas in this line of endeavor should be obtained through an occasional round-table discussion and through correspondence.

In the final analysis, strict co-operation between the central stations, the kitchen supply houses and the manufacturers will be a big factor in increasing sales volume and will reflect in added revenues and profits to all.

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*Industrial Heating**

HOW many companies really know the magnitude of the industrial heating load that is available as potential load now in existence along their lines, not one that may or may not develop? It is safe to say that few companies have this information.

The reason why they do not have this information seems to be that few intelligent canvasses have been made to determine such potential load. Further, that load is to a certain extent in a state of flux. New processes requiring electric heat continually are being developed and new equipment requiring the use of electric heat is being perfected. Only within the last month has an electric furnace for melting aluminum been perfected.

Some of this electric heating load can be obtained as off-peak business and hence is highly desirable. All of it is not only high-load-factor business, but also operates with high power factor.

* Report of the industrial heating committee. T. M. Gibbes, Puget Sound Power & Light Company, chairman.
Idaho Power Company: J. B. McLain.
Mountain States Power Company: Z. E. Merrill.
Northwestern Electric Company: B. N. Peterson.
Pacific Power & Light Company: W. H. McMurray.
Utah Power & Light Company: G. B. Walker.
The Washington Water Power Company: E. E. Schofield.

Advantages to the User

The advantages of electric heat to the user are many. It is highly efficient, it is simple to apply, close automatic temperature control can be obtained, it is safe when properly applied, and it is clean.

Manufacturers always desire to obtain a better product at a lower cost, and this usually can be brought about by the use of electric heat. There are no variables in electric heat. The human factor, always to be reckoned with when fuel is used, is displaced by accuracy that is absolute, because automatic.

Economies that result from the use of electric heat are four-fold:

1. Reduction of rejects.
2. Minimizing of required factory space.
3. Reduction in amount of labor, and creation of better working conditions.
4. Reduction of fire hazard.

It is obvious that perfectly even heating, at ascertained correct temperature, will result in a product most likely to comply with standard requirements.

Electric heating equipment usually occupies a much smaller area than that taken up by fuel-fired types, where space is required for fuel storage, piping and other related apparatus. This saving of space is the more valuable because the comparatively slight radiation from an electric furnace allows other processes to be carried on close by and in entire comfort.

Electric heating also turns out material that can be further worked at the least expense. Metal that is to be machined, for example, can be cut only as fast as the hardest parts permit. These hard spots, which slow up work, do not appear after electric annealing.

Men work best when they work in comfort. Radiation from the electric furnaces is so small that it does not interfere with correct working conditions, even close at hand. There are no fuel gases to escape; the air and surroundings stay clear and hygienic.

Fire hazard, an ever present threat of financial loss and sustained production, need never be a source of worry when electric heating equipment is correctly installed.

Methods of Securing the Load

The first step to be taken toward getting a heating load is to make an analysis of the field. Up-to-date and reliable information on potential heating loads will make possible the setting up of quotas. Establishment of quotas serves as an excellent stimulant to the sales effort.

With the surveys completed and the results analyzed, the next important step is to formulate a definite plan of getting the load onto the lines. The sales plan will vary in different localities, but there are certain lines that can be followed with considerable success in practically all cases. Statistics which have been gathered during the survey have little sales value until they are tabulated, co-ordinated and clarified into comprehensive reports to the individual industrial plants. Such reports should cover present costs on heating apparatus compared with estimated cost when some operations are electrified. Reports should be as complete as possible, and all statements should be backed up by established facts.

Inasmuch as electric power companies generally do not sell electric heating equipment, much depends upon the co-operation that can be obtained from the manufacturers of this equipment.

It has been stated that the chief duty of the selling

force is to get the electric heating load on the lines, but it is equally important that it should be kept there. The latter function is just as important as the former, and in the early stages of the promotion of electric heat in any territory an effort will have to be spent in keeping installations sold.

PROMOTIONAL RATES COMMITTEE

*Promotional Rates**

AS A RESULT of public demand and in some cases political expediency, rates have been reduced in various communities by reducing the top rate only. The reduction in one community immediately arouses the desire of the customers in another community for a similar reduction, until we are faced with the situation that our top rate already has been reduced to a point below cost, and it will be only a short time until we are called upon again for further reductions. We have not yet been able to increase the average consumption per customer to a point which will offset the loss resulting from serving a large percentage of limited-use customers. This committee believes that it is a problem of education to acquaint customers with conditions, and to show them the fallacy of expecting the customer making full use of electric service to carry the burden imposed by the minimum customer. Further, it appears to be the duty of rate engineers to design rate structures to the end that the charges to the minimum customer will gradually be raised or that his requirements of electric service will be extended so that he may enjoy the many benefits of complete electric service at a reasonable cost, and at a reasonable return to the utility.

The utility's program tends to teach the average customer to think of electric service in terms of cost per kw.-hr. rather than the value of the service supplied in terms of comfort to himself.

Statistics are published showing the average cost per kw.-hr. for domestic electric service at approximately seven cents, and the general impression by the public is that the utility offers electric service at this figure, whereas actually the utility offers electric service to the customer at a price as low as one cent per kw.-hr., and the customer's average cost per kw.-hr. depends entirely upon his use or acceptance of the service.

As an example of this, suppose you wish to publish a book and the publisher quotes you a price of $2,600 for the first thousand copies, and $400 per additional thousand. If your market for this book is limited to 2,000 copies, the average cost would be $1.50 per copy, and yet the publisher did not quote you a rate of $1.50 per copy. If on the other hand you need 5,000 copies, the average cost per copy would be only 84 cents. Therefore, cost comparisons of this kind are misleading unless all the facts are known. In the case of the publisher, there is nothing mysterious as to why his charge for the first one thousand copies is high. We know that the cost of setting up the press is much greater than the actual printing costs, but we have not educated the public to apply this reasoning to the utility situation.

Essential to Know Cost

It is a fundamental principle in any sound business that until the cost of an article is known, the selling price cannot be determined intelligently. The same principle should be followed by the utility in selling its services, and the cost of serving should be broken into its various components to determine their relation.

You probably will say that cost analyses are inaccurate, and depend too much upon the judgment of the person making them. While this is true to a certain extent, all methods of allocating costs, if applied to the problem intelligently by capable persons, will produce results within practical limits of accuracy. It is necessary to allocate these costs against the various classes of service, and for the sake of brevity we are considering only that class of service designated as domestic or residential lighting. Also we will touch briefly upon the combined residence load as expanded by the use of range, refrigerator and other appliances.

The accompanying set of curves which we now will discuss, represents graphically one method of cost allocation, and we are using them solely for the purpose of illustration, to show that the cost of serving a customer varies with his use of energy, and to show the danger of low minimum charges and low top rates.

Analysis of Cost of Domestic Service

Referring to Fig. 1, we have pictured graphically the development of costs to serve residential customers. This particular curve represents the components of cost on a particular property. The shape and values of this curve will vary for local conditions. Therefore, these values cannot be taken to apply to all properties.

One component of cost which is constant for all customers regardless of energy consumption is customer expense, and includes such cost items as meter reading, billing, maintenance of meters and services, commercial

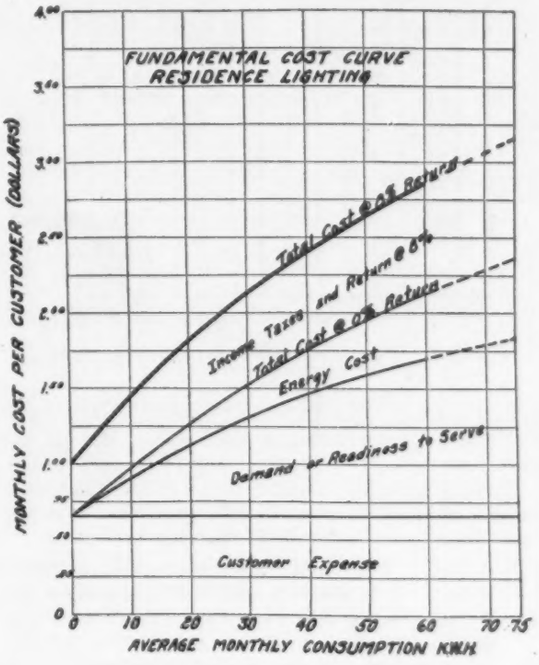

Fig. 1. Factors of cost to serve residence lighting customers

* Report of the promotional rates committee. H. G. Kelsey, Grays Harbor Railway & Light Company, chairman.
Northwestern Electric Company: D. F. McCurrach.
Pacific Power & Light Company: W. T. Neill.
Pacific Northwest Public Service Company: F. H. Murphy.

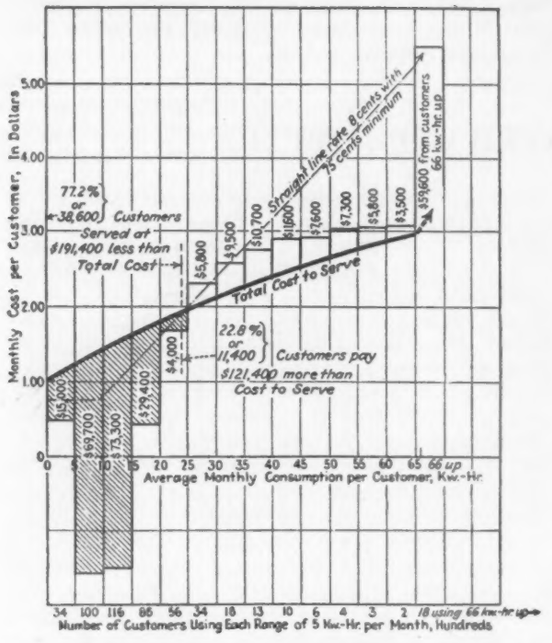
Monthly Cost per Customer, In Dollars
77.2% or 38,600 Customers Served at $191,400 less than Total Cost
22.8% or 11,400 Customers pay $121,400 more than Cost to Serve
Straight line rate 8 cents with 75 cents minimum
Total Cost to Serve
$59,600 from customers 66 kw.-hr. up
Average Monthly Consumption per Customer, Kw.-Hr.
Number of Customers Using Each Range of 5 Kw.-Hr. per Month, Hundreds

Fig. 2. Typical straight-line rate showing profit and loss for residence customers

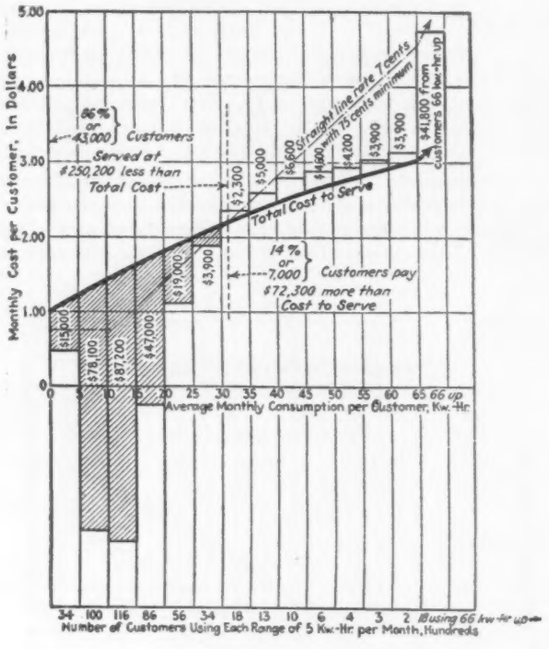
Monthly Cost per Customer, In Dollars
86% or 43,000 Customers Served at $250,200 less than Total Cost
14% or 7,000 Customers pay $72,300 more than Cost to Serve
Straight line rate 7 cents with 75 cents minimum
Total Cost to Serve
$41,800 from customers 66 kw.-hr. up
Average Monthly Consumption per Customer, Kw.-Hr.
Number of Customers Using Each Range of 5 Kw.-Hr. per Month, Hundreds

Fig. 3. Effect of reduction on straight-line rate

and advertising expenses, and all operating items which are directly proportional to the number of residence customers served. This item also includes a proper pro-rata of general administrative expense chargeable to this class of service. In this particular case the customer expense amounts to 64 cents per month.

The next component which we call demand or readiness-to-serve cost, includes all of the operating expenses chargeable to the residence class, resulting from the demand which its customers impose upon generating, transmission, and distribution equipment. This component increases proportionately with the monthly consumption, because the average load factor of a residence remains fairly constant and the increase in consumption therefore is due to the increased demand.

The next component we call energy cost, and it includes those costs of production which increase in direct proportion to the number of kw.-hr. used. This component is a very small part of the total cost.

The last component includes taxes and eight per cent return on the utility's investment for this class of service based upon demand. The resultant curve we will call the "total cost to serve at eight per cent return."

Taking this curve for the purpose of illustration only, we note that the minimum cost per month is $1, and that the first 10 kw.-hr. used by the customer cost approximately $1.50 or about 15 cents per kw.-hr., and that 65 kw.-hr. per month cost only about $3, or less than 5 cents per kw.-hr.

Effect of Straight-Line Rate

Referring to Fig. 2, we have the same curve labeled "total cost to serve," and a dotted line representing a straight-line rate of eight cents per kw.-hr. with a minimum of 75 cents per month.

It may be noted that these curves cross at 24 kw.-hr. per month, and at that point only is the price correct

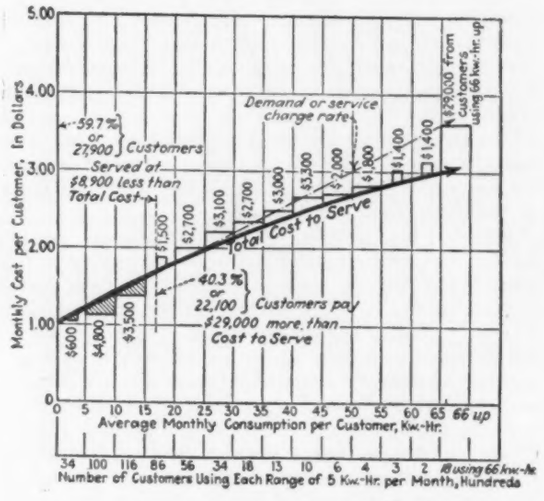
Monthly Cost per Customer, In Dollars
59.7% or 27,900 Customers Served at $8,900 less than Total Cost
40.3% or 22,100 Customers pay $29,000 more than Cost to Serve
Demand or service charge rate
Total Cost to Serve
$29,000 from customers using 66 kw.-hr. up
Average Monthly Consumption per Customer, Kw.-Hr.
Number of Customers Using Each Range of 5 Kw.-Hr. per Month, Hundreds

Fig. 4. Effect of a promotional form of rate

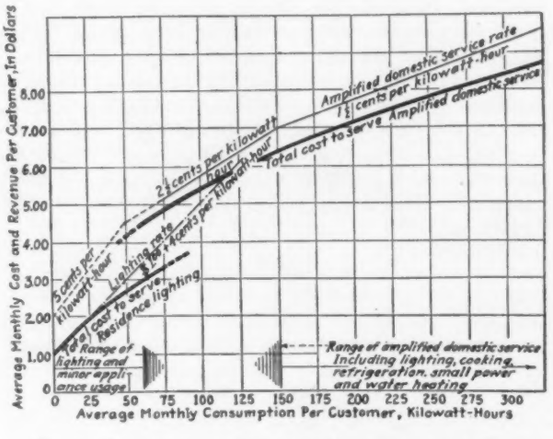
Average Monthly Cost and Revenue Per Customer, In Dollars
Amplified domestic service rate 1½ cents per kilowatt-hour
Total cost to serve Amplified domestic service
2½ cents per kilowatt-hour
5 cents per kilowatt-hour
Lighting rate 3 cents per kilowatt-hour
Total cost to serve residence lighting
Range of lighting and minor appliance usage
Range of amplified domestic service including lighting, cooking, refrigeration, small power and water heating
Average Monthly Consumption Per Customer, Kilowatt-Hours

Fig. 5. General form of promotional rate for full use domestic service

from a cost standpoint. Below that point the rate is too low, and above it is too high. Let us see what this means as applied to the residential class of service. The lower abscissa of this chart represents the number of hundreds of customers, classified by use, falling in each block of 5 kw.-hr. per month. Therefore, computing the revenue from the total number of customers using less than 24 kw.-hr. per month in blocks of 5 kw.-hr. per month, and subtracting this figure from the revenue necessary to return the cost of service, we find that the shaded area represents $191,400 less than total cost, and we also find that 77 per cent of the total customers served by this particular utility were being served below cost. Applying the same reasoning to those customers served at excess cost, we find that more than 22 per cent are paying a total of $121,400 more than cost-to-serve. This excess revenue does not balance the loss resulting from the 77 per cent block of customers, and at the same time does not encourage greater use of energy by the class as a whole.

By referring to Fig. 3, the effect of a reduction on a straight-line rate from eight cents to 7 cents may be seen graphically. We find that, instead of 77 per cent, there are 86 per cent of the customers served at $250,200 less than total cost, and 14 per cent pay $72,300 more than cost to serve. The reduction in rate has not yet accomplished the possibility of encouraging greater use of electric service.

Very few companies are using the old straight line rate, but a good many of the sliding scale rates are so designed that, within the limits of use by the majority of lighting customers, the effect is the same as a straight-line rate because the top rate is below the cost to serve.

Effect of Promotional Rate

Referring to Fig. 4, the effect of a promotional form of rate, which is designed to follow very closely the cost-to-serve, may be seen. There still are 59 per cent of the customers being served at less than total cost, but to the extent of only $8,900 as compared to the previous figures of about $200,000. Further, 41 per cent of the customers pay only $29,000 more than cost-to-serve, leaving a margin for further reductions to the latter class.

As to whether the rate should be based on service, area, or number of rooms, or even the connected load or measured demand, as a proper method of introducing a fixed price sufficient to cover the charges which the companies must meet in delivering the first few kw.-hr. per month, or whether this fixed charge should be made to include a few kw.-hr., is entirely up to the judgment of the local management of the various utilities. In some way a flat or minimum charge should be guaranteed by each customer high enough to cover these fixed costs.

In Fig. 5, are shown the cost of serving residence lighting only, and residence lighting combined with residence power. There is a certain point between 50 and 75 kw.-hr. per month where the cost-to-serve increases. This is due entirely to the installation of the range or larger appliances that increase the customer's demand. A combination service rate provides for lighting, cooking and water heating at various prices reasonable to the operation of the various appliances mentioned and, competitive with other fuels, makes it possible for the customer to enjoy to the fullest advantage the benefits of complete residence electric service at a reasonable rate.

The Committee acknowledges and appreciates the courtesy of W. S. Leffler of the firm of Lacombe and Leffler, Consulting Engineers, New York, for permission to publish the curves contained in this report.

WIRING SALES COMMITTEE

*Safe and Adequate Wiring Needed for Rural Electric Service**

A PROBLEM confronting most power companies is how to obtain safe and adequate wiring in rural communities where regulated inspection service is not available. Experience has proved that most farmers are mechanics of some sort, and feel that they are competent to do their own wiring. Results very often are far from satisfactory. In an endeavor to solve the problem it has been thought advisable to furnish our rural customers, who anticipate doing any wiring, with sufficient information to enable them to do the work in a manner acceptable to the utility that is to serve them. This can be accomplished best through the medium of an inexpensive pamphlet, containing wiring information in a simplified form, together with wiring diagrams, that can be understood readily.

Necessary data, together with simple diagrams, can be reproduced on a small folder of three or four pages, similar to the sample reproduced herewith. The subject matter, of course, may be revised to satisfy the needs of different companies. This pamphlet can be sufficiently inexpensive to enable the utility to distribute them liberally and without charge. The subject matter treats chiefly with the wiring from the service outlet to the cabinet box, with very brief suggestions as to the interior wiring. (See supplemental report immediately following this report.)

Results Anticipated

1. To eliminate exposed service wires.
2. To obtain fire-proof enclosure for main line switch and branch block.
3. Ample capacity for future expansion.

Conclusion

This method of dissemination of information has been tried out in a limited way and has proven very satisfactory. So much so that the utility having tried it, is enlarging its use. It is the suggestion of the committee that it be tried out by other member companies of the association.

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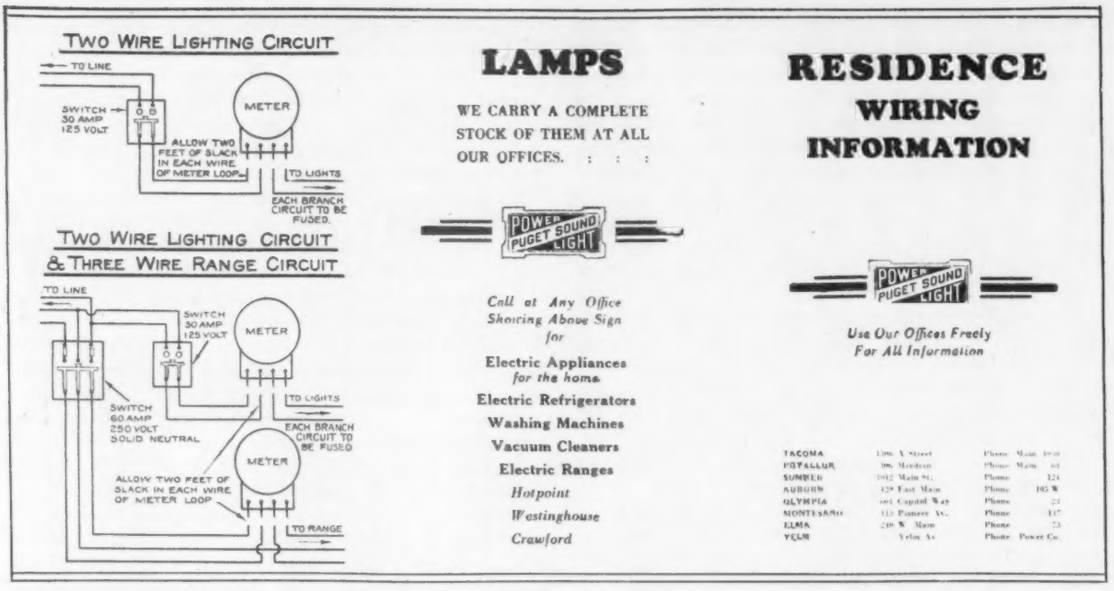
* Report of the wiring sales committee. F. H. Kerr, Puget Sound Power & Light Company, chairman. H. R. Kruse, Puget Sound Power & Light Company, vice-chairman.
Pacific Northwest Public Service Company: W. D. Williams.
Utah Power & Light Company: W. M. Scott.
The Washington Water Power Company: L. V. Ross.



One side of printed sheet containing wiring information that will fold conveniently into six-page folder, as issued by Puget Sound Power & Light Company. Other side of sheet contains text

*Recommended Wiring Regulations for Rural Residences**

THE text from a typical instruction pamphlet, such as referred to in the preceding report, is reproduced in full in the following paragraphs.

1. *Service Entrance*—

The wiring connections from your switch box to our service wires should be encased in a rigid metallic conduit of proper size (see Table I) which must be fastened to the switch box by means of a locknut and bushing and fitted with an approved service head attached at the point of contact with our lines. The location of the service entrance should be at a point nearest available to our lines. The service entrance should be sufficiently high to be well out of the reach of persons standing on the porch or ground.

Wire used in the service entrance should be not less than:

No. 8 B.&S. standard 600-volt rubber-covered for residence 2-wire 110-volt lighting.

No. 6 B.&.S. stranded standard 600-volt rubber-covered for residence 3-wire combination lighting, range or hotplate, and water-heater installation.

No. 4 B.&S. stranded standard 600-volt rubber-covered for residence lighting, range, water heater, farm light and up to 5 hp. in motors.

No splice will be permitted in wire between main line switch and service entrance.

2. *Switch*—

Main switch and fuses should be contained in an approved steel cabinet with knockouts in sides and bottom. The main line switch should have a carrying capacity of not less than:

30 amp. for 2-wire, 110-volt residence light.

60 amp. for 3-wire, 110/220-volt residence light and range combination.

100 amp. for 3-wire, 110/220-volt residence light and range combination, and farm lights with 5 hp. in motors.

* Supplement to report of the wiring sales committee.

TABLE I—Wire and Conduit Sizes

Size of Wire	Capacity in Amps.	Number of wires in one conduit (Minimum size of conduit)							
		1	2	3	4	5	6	7	8
14	15	½	½	½	¾	¾	1	1	1
12	20	½	½	¾	¾	¾	1	1	1
10	25	½	¾	¾	1	1	1	1¼	1¼
8	35	¾	¾	1	1	1	1¼	1¼	1¼
6	50	½	1	1¼	1¼	1½	1½	2	2
4	70	¾	1¼	1¼	1½	2	2	2	2

TABLE II—Fuse Sizes.

Circuit	Size of fuse
Main line using No. 4 service	100 amps.
Main line using No. 6 service	60 amps.
Main line using No. 8 service	30 amps.
Range	60 amps.
Water heater	30 amps.
Branch light circuits	15 amps.
Convenience outlets	20 amps.
¾ h.p. motor	30 amps.
½ h.p. motor	20 amps.
⅓ h.p. motor	15 amps.
¼ h.p. motor	15 amps.

On all three-wire installations, the neutral wire must not be fused, but should be connected solid from the switch to the branch circuit fuses. Each separate circuit should be fused according to Table II. The switch box should be of sufficient size for two or more additional circuits to take care of your additional wiring from time to time. If you contemplate the installation of an electric range, a fuse block should be provided for in the bottom of the cabinet with a carrying capacity of 60 amperes, and for a water heater, 30 amperes. (Flat-rate water-heater circuits must have conduit continuous from heater to branch fuses.) All wires coming out of the switch box unless in conduit must be protected with porcelain bushings.

A ground wire of not less than No. 8 must be connected from the neutral wire on the service side of the main line switch to a permanent ground. This ground can be either a water pipe or driven ground. If a driven ground, the ground rod should be at least ten feet in length and driven flush with the ground.

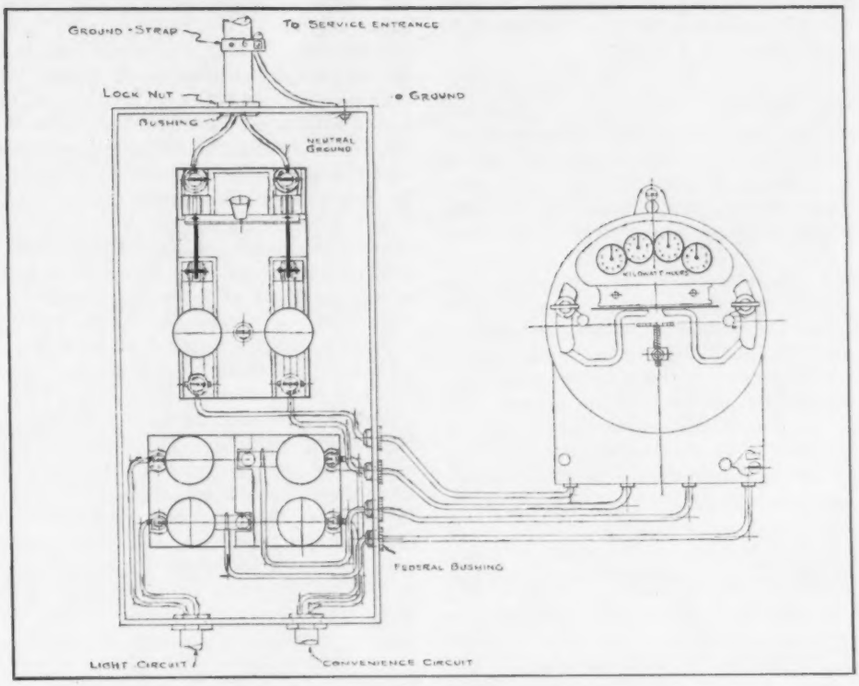


Fig. 1. Recommended connections for 110-volt two-wire residence lighting service

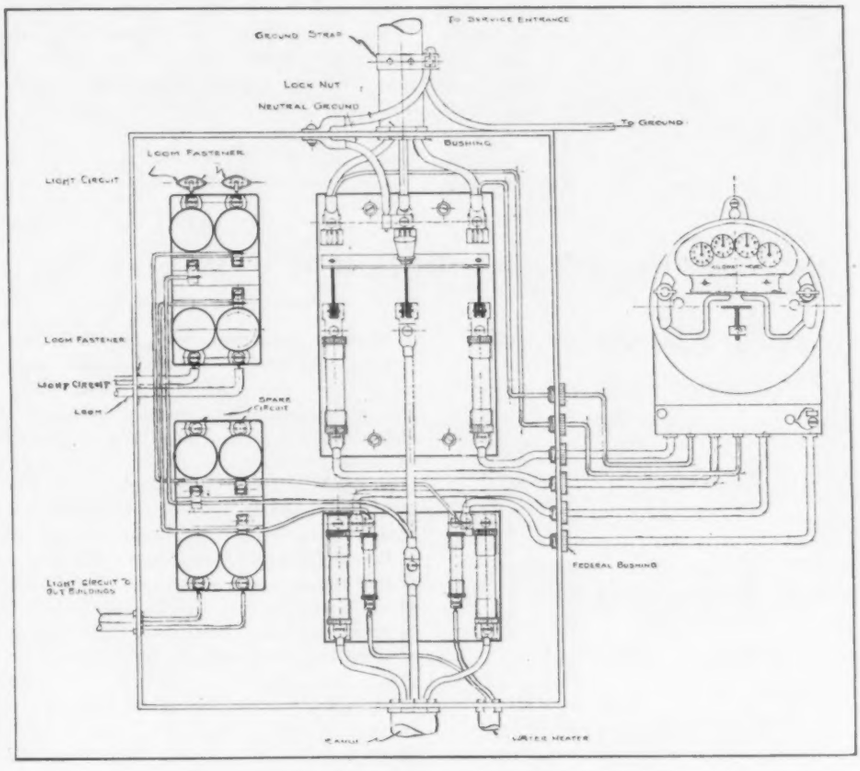


Fig. 2. Recommended connections for 110-220-volt three-wire residence combination light, range, and water-heater service

All ground connections should be made with suitable ground clamps. All conduits should be connected to ground by not less than No. 8 wire.

3. *Meter Location and Meter Loop—*

A meter loop must be provided and wires must extend not less than eighteen inches beyond the switch box. (See Figs. 1 and 2 for connections.)

Meter loop and meter location must not be more than seven feet or less than four feet above or below ground or porch.

Meter loop should be as near main line switch as practical.

When main line switch and meter are mounted on walls open to weather, suitable covering must be provided to keep both meter and switch dry. Also protection must be afforded the meter from damage and vibration. When a box is used to house the meter a space of not less than 12 in. wide, 14 in. long, and 8 in. deep is required for each meter.

The meter must be located in a place easily accessible to the meter reader and meter tester at all times without entering the main part of the building. Location of meter inside house or enclosed porches will not be approved.

4. *House and Out-building Circuits—*

Each house should have at least two or more fused circuits within the building. Motors of 1 hp. or more, brooders, incubators, and large appliances should be on separate fused circuits using not less than No. 12 wire.

5. *Inside Wiring—*

Each room of the house should have at least one ceiling outlet for a lighting fixture and a wall switch of the tumbler type, placed at a recommended height of 4½ feet above the floor. Convenience and light outlets in basement should be in conduit. The living room should have one or more duplex outlets for floor lamps and radio set. The dining room should have at least one duplex outlet for such appliances as grills, percolator, toasters, waffle irons, etc. Two convenience outlets should be conveniently placed in the kitchen for small appliances, iron, washer, etc.

Bathroom and bedroom should have at least one outlet for vacuum cleaner or air heater. Only porcelain type receptacles and convenience outlets should be used in the bathroom. Each porch should have a light provided with an inside wall switch. Stairways should be wired with a three-way circuit so that the light may be turned on or off at either top or foot of stairs. All inside wire should not be less than No. 14 and all convenience outlet circuits should be No. 12 rubber-covered wire. All joints should be soldered and double taped, one layer of rubber tape topped by a layer of friction tape. Porcelain knobs and tubes must be used to keep the wiring clear of all surfaces. Wires should be spaced not closer than five inches, and be at least one inch from near-by surfaces. Where this spacing is not possible it is necessary to encase the wire in loom tubing, flexible or rigid conduit. Loom should be continuous from porcelain to porcelain. Do not use a short piece of loom to protect a wire by taping it to the wire as the tape will eventually come loose and the loom will slip. Use knobs where you can run your wire parallel with and on the inside of ceiling, rafters or wall joists or run at right-angles to them. Always pull your wire tight so that it will not droop and come in contact with exposed surfaces.

All outdoor wiring exposed to the weather should be not less than No. 8 weatherproof, using approved be used in providing for outdoor lighting. Conduit is outdoor service knobs. Weatherproof sockets should recommended for barn lighting due to ammonia fumes from animals which would collect on exposed rubber-covered wire. Do not confuse electrical conduit with water or gas pipe. Electrical conduit is especially treated on the inside to prevent damage to insulation.

Do not overfuse, use pennies as a substitute, or use a blown fuse by cutting it so that it will make contact. Always replace fuses with one of the same size as the one blown, and throw away the old. Fuses are your protection—use them.

For further information concerning electric wiring, consult your electrician or the power company.

RURAL ELECTRIC SERVICE COMMITTEE

*Status of Farm Electric Service as of January 1, 1930**

THE principal work of this committee consisted of attempting to prepare a report for the national committee, this report to record progress made during the past ten-year period and to show the present status of farm electrification. Questionnaires were sent to member companies in the association territory asking for the information requested by the national committee.

Member companies were, in most cases, slow in reporting and the committee finds upon comparing figures with those submitted in previous years that either figures submitted in the past have been inaccurate or that there are inaccuracies in this year's figures. However, we feel that in all probability figures for this report are more accurate than previously for the reason that a greater appreciation of the value of accurate statistics on rural lines exists in the minds of company officials than in the past. We find that we cannot make a ten-year comparison from information available. However, we submit the following comparison between the years 1929 and 1930 of farms on the lines of central stations of the Northwest:

	1929	1930
Washington *	34,443	32,809
Oregon	11,428	15,146
Idaho	7,215	10,171
Montana	663	1,394
	53,749	59,520

* Probable inaccuracy.

* Report of the rural electric service committee. George Hibbert, Pacific Power & Light Company, chairman.
The California Oregon Power Company: T. H. Delzell.
Eastern Oregon Light & Power Company: J. P. Lottridge.
Grays Harbor Railway & Light Company: H. G. Kelsey.
Idaho Power Company: R. S. Overstreet.
Mountain States Power Company: H. C. Wells.
Northwestern Electric Company: F. C. Carleton.
Pacific Northwest Public Service Company: H. M. Hamilton.
Peoples West Coast Hydro-Electric Corporation: S. K. Pardee.
Puget Sound Power & Light Company: J. C. Scott.
Utah Power & Light Company: E. R. Owen.
The Washington Water Power Company: W. W. Skuse.

Member Companies Changing Accounting Systems to Show Rural Customers

This committee wishes to report that three member companies have set up classifications within their accounting systems, or have changed their accounting during the past year, so that from the classifications established, rural business, and particularly farm business, can be segregated. These figures will not be available until 1931 and we are certain that other companies will fall in line rapidly.

TABLE I—Rural Electric Service Report 1930. Statistical Data obtained from Questionnaires sent to Member Companies.

1. Number of farms served by states as of 1-1-30.
&
2. Energy Used.

	No. Farms Served 1-1-30	Energy Used in 1929
Washington	32,809	71,091,404
Oregon	15,146	26,361,071
Idaho	10,171	22,990,613
Montana	1,394	418,200
	59,520	120,861,288 KWH

3. Figures by companies giving square miles of territory served and total miles of distribution lines outside of towns of 1,000 population or over, or towns having essentially urban characteristics.
&
4. Chief agricultural uses of electric service by companies.

	Total Miles	Total Sq. Miles	Uses of Service
Montana Power Co.	307	Not given	Not given
Wash. Water Power	940	Not given	1. Irrigation 2. Spray Plants 3. Dairying 4. Poultry 5. Household
Northwestern Electric Co.	479	570	1. Household 2. Water Supply 3. Prune Drying 4. Poultry
Pacific Pr. & L. Co.	1,478	6,521	1. Irrigation 2. Household 3. Poultry 4. Dairying
Missoula Pub. Serv. Co.	77	Not given	Not given
Grays Harbor Rlwy. & L. Co.	68	Not given	1. Household 2. Poultry
Idaho Power Company	1,762	2,200	1. Household 2. Dairying 3. Poultry
Mountain States Pr. Co.	233	5,463	1. Household 2. Poultry 3. Water Supply 4. Fruit
Puget Sd. Pr. & L. Co.	4,133	30,000	1. Irrigation 2. Poultry 3. Dairying 4. Household
Eastern Ore. L. & Pr.	109	3,760	1. Household 2. Irrigation 3. Dairying
Portland Electric Pr. Co.	1,541	1,311	1. Household 2. Water Supply 3. Dairying 4. Poultry
California-Ore. Pr. Co.	454	15,508	1. Irrigation 2. Household 3. Poultry 4. Dairying 5. Fruit

Developing Use of Electricity on the Farm

During the past year, at least three of the largest Northwest companies have employed agricultural agents for the purpose of developing the use of electricity on the farm and to assist in educating company organization so that rural business may be handled to a better advantage. Informal reports show that these agricultural men are carrying on educational work through the use of portable exhibits, are using space at local and state fairs and are putting farm customers on the mailing lists of numerous publications, including government reports, and also are taking care of field contracts where special service of any character is required.

Schools

Schools for rural service men were not conducted in this geographic division in 1929. It is expected that one or more schools will be held in 1930.

Research Work

Research work has been carried on by the state committees on the relation of electricity to agriculture, and in view of the inquiries coming to member companies of this territory we feel that this work is rapidly being recognized and accepted and is showing very satisfactory results.

Spokane Meeting

With the exception of an informal meeting between Dr. A. E. White, a few members of the rural electric service committee and certain company executives, no meetings were held prior to the mid-winter conference of the Commercial Section, which was held in Spokane, Feb. 13-15. Friday afternoon of that conclave was given over entirely to the rural electric service committee. The following papers were presented:

"Farm Electrification" by F. E. Price, Project Supervisor, Oregon, C.R.E.A., Corvallis, Oregon.

"What Electric Service Means to Agriculture as Viewed by the Agricultural College" by Hobart Beresford, College of Agriculture, University of Idaho, Moscow, Idaho.

"Economic Value of Statistics on Rural Lines" by A. C. McMicken, Pacific Northwest Public Service Company, Portland, Oregon. (Extemporaneous.)

TABLE II—Farm electrification survey, January 1, 1930.

Name of Company		No. Farm Customers 1-1-29	Those Connected in 1929	Total 1-1-30	KWH Consumed by Farms in 1929	Annual KWH per Farm 1929	Miles Rural Line 1-1-29	Miles constr. in 1929	Total
Montana Pr. Co.	Mont.	738	100	838	251,400	300	286.49	20.00	306.00
Wash. Water Pr.	Wash.	3,021	277	3,298	23,840,917	7,138	721.27	46.00	767.20
	Idaho	240	8	248	367,155	148	170.34	2.00	172.30
Northw. Elec. Co.	Wash.	1,641	1,359	3,000	900,000	300	287.69	140.31	428.00
	Ore.	7	143	150	*45,000	300	8.52	41.48	51.00
Pac. Pr. & L. Co.	Ore.	1,484	162	1,646	1,867,719	1,135	313.89	74.51	388.40
	Wash.	5,695	1,014	6,709	16,177,496	2,341	829.35	136.15	965.50
	Idaho	259	5	264	208,899	421	76.40	47.52	123.92
Missoula Pub. Serv. Co.	Mont.	506	50	556	*166,800	*300	72.00	5.00	77.00
Grays Harbor Rly. & Light Co.	Wash.	20	25	45	*13,500	*300	54.25	13.75	68.00
Idaho Pr. Co.	Idaho	7,917	2,121	10,038	33,832,143	3,370	1,309.00	452.00	1,761.55
Mt. States Pr.	Ore.	1,819	*67	1,886	1,979,456	1,049	**422.00	11.00	233.00
Puget Sound Pr. & Light Co.	Wash.	19,213	842	20,055	29,985,714	1,495	3,698.00	435.00	4,133.00
Eastern Ore. L. & Power Co.	Ore.	313	62	375	*112,500	*300	.....	.....	109.00
Portland Elec. Power Co.	Wash.	100	92	192	172,800	900	.....	.....	20.00
	Ore.	6,028	1,438	7,466	3,911,279	524	.....	.....	1,521.00
Utah Power & Lt. Co.	Idaho	2,000	....	.....	.....	.....	.....	.....	.....
	Utah	10,114	....	.....	.....	.....	.....	.....	.....
Cal.-Ore. Pr. Co.	Ore.	**2,176	....	2,064	7,096,229	3,438	.....	.....	453.47

Totals are not given because of incomplete reports.
*These figures estimated as information not available from these companies.
**Inconsistencies due to lack of accurate figures in the past.
Where space is left blank, no figures were available for that item.

"Value of Executive Demand in Building Rural Load" by J. C. Scott, Puget Sound Power & Light Company, Seattle, Wash.

"Developing a Local Organization for Rural Extensions and Farm Load Development" by W. M. Hamilton, Pacific Northwest Public Service Company, Salem, Oregon.

The above papers, with the exception of Mr. McMicken's, which was not presented in written form, are appended as supplements to this report.

Subcommittees Suggested

In conclusion, this committee offers the following suggestions:

First, that the chairman of the rural electric service committee hold at least three committee meetings prior to the mid-winter conference. Attention is called to the fact that this geographic division covers five states, making it particularly difficult for the committee members to meet together and participate in any of the discussions or committee work. As an offhand suggestion, we believe meetings should be held in Portland, Spokane, and Boise.

Second, we suggest that the activities of this committee be broadened to the extent of setting up subcommittees as follows:

Equipment

Engineering and Construction (highway lighting as related to rural extensions)

Rates, Extension Policies, Promotional Work

Research

The first subcommittee mentioned should consist principally of agricultural agents. The second committee, covering engineering and construction, would be to a certain extent a duplication of the work carried on by the Engineering Section of the Association. However, attention is called to the fact that the men actually engaged in rural service work seldom have the benefit of any discussion of these problems and we feel that, if not in the above manner, at least some means of co-ordinating the work of these committees should be brought about. The committee on rates, extension policies, and promotion might also be considered as duplicating the work of other committees. However, we offer this suggestion for the same reason that we suggest the subcommittee on engineering. The research subcimmittee, of course, should be made up primarily of the men engaged in C.R.E.A. work together with such other members of the committee as will fit into such work.

We feel very much gratified with the interest shown in the program submitted this year and are very appreciative of the co-operation of member companies, and particularly the interest shown by the executives. But we do feel that, if this committee is to accomplish a great deal, the scope of its work should be broadened as outlined above.

*Rural Electrification**

By F. E. Price

THE Oregon Committee on the Relation of Electricity to Agriculture was organized for the purpose of determining and disseminating facts regarding the use of electricity for profit and convenience on Oregon farms. It is desired to tell some of the facts determined by this committee and the Oregon State College Experiment Station relating to the use of electricity for profit and convenience.

Irrigation of small fruits at the Oregon Experiment Station was taken up as a major project in 1927. The blackberry probably reached maturity in 1929, while the loganberries will reach maturity in 1930 and the evergreens in 1931.

Results of Irrigation of Small Fruits—Oregon State College Experiment Station

Irrigation increased the average size of the berries from twenty to forty per cent. Better flavor was developed by the irrigation of raspberries and loganberries. All of the irrigated berries stood up as well or better in marketing than berries from the dry plots. Due to the increased size of the irrigated berries, pickers did not like to pick berries that were not irrigated so that a rotation system was worked out, giving all pickers an equal share of the dry and irrigated berries. There also was a preference for the irrigated berries shown by the canning department.

Results with strawberries were of particular interest. First, the Ettersburg 121 strawberry has not responded to irrigation. A greater tonnage of berries can be obtained with no irrigation than with irrigation. Second, strawberries have been planted the first of August and a profitable tonnage secured the following spring. This eliminates the necessity of land lying idle a season, as is the common practice in developing strawberry plantings. Third, the Marshall strawberry, one of the leading varieties for fresh fruit and barreling, increased 67.9 per cent in 1929 and at four cents per pound gave an increased return per acre of $170.21 with 5¼ tons per acre.

Another quite undeveloped field for irrigation in western Oregon is pasture, particularly for dairy cows and also for sheep.

Irrigation of Pasture

A 12-acre field of Ladino clover was seeded in the fall of 1927 at the Experiment Station. It was very heavy, poorly drained soil and had not been farmed for several years due to the low returns that could be obtained from it. The field was fairly well prepared for distribution of water by the strip border method before seeding. The field first was pastured in August

* Supplement No. 1 to the report of the rural electric service committee.

TABLE I—Results of irrigation of small fruits as reported by Oregon State College Experiment Station.

Kind of Fruit	Lbs. Yield per Acre		Per Cent Increase	Value per Lb. (Cents)	Value per Acre		Increase Income per Acre
	Dry	Irrigated			Dry	Irrigated	
Marshall strawberry	6,265	10,523	67.9	4	$250.61	$420.82	$170.21
Ettersburg strawberry	4,166	3,777	9.3	7	291.67	236.44	55.22
Loganberry	5,830	6,597	13.2	4	233.22	263.90	30.68
Red raspberry	4,446	8,394	88.8	8	355.72	671.54	315.82
Black raspberry	2,447	3,161	29.1	6	146.86	189.67	42.81
Evergreen blackberry	5,284	10,415	97.1	4	211.36	422.36	211.00

1928, and the stand of clover was better in October when the cows were taken off the pasture.

Results of the 1929 pasture season show very clearly the value of irrigated pasture on the dairy farm of western Oregon. This pasture produced 7,032 cow-days per acre or slightly more than 3 cows per acre for six months. The grass value of the pasture in replacing hay, silage and grain was $69 per acre. Net returns amounted to $48.73 after deducting labor of irrigation, a 10 per cent depreciation on a $100-per-acre irrigation equipment investment, and interest and taxes on a $100 land value. Water was supplied by gravity. Four inches were used per irrigation and four irrigations were applied, and the fifth would have increased the returns due to the dry fall. September rains were not sufficient as it was thought they would be.

Power cost to pump four acre-inches against a 50-ft. lift with power at three cents per kw.-hr. would be approximately $1, (one sec. ft. and 10-hp. motor) or with a 25-ft. lift, one-half that amount, or 50 cents. This is an estimated cost per acre per irrigation for power if this had been a pumping project of 25- or 50-ft. lift. Four irrigations, there, would cost $4 per acre at a 50-ft. lift or $2 at 25-ft. lift.

Deducting the $4 from $48.73, the actual net return would have been $44.73 if pumping against a 50-ft. head. It is assumed that $100 per acre, the amount allowed for the distribution system investment in determining the net returns for 1929, would be sufficient for the pumping equipment as well.

Summer pasture for dairy cows has a far reaching effect in the Willamette Valley. The producing season for pasture without supplemental moisture is ended by June 15 or July 1 and, furthermore, it is quite inferior to the usual irrigated pasture. The unirrigated pasture is so dry and dormant when fall rains begin in September that it is of little value until the following spring, whereas the irrigated pasture starts September in good moisture and is a heavy producer through September and October. An irrigated pasture changes July, August and September from months of low production to months of high production, and when weather conditions and prices are best.

Irrigated pasture requires a minimum of labor for feed production during the six-month pasture season. It took 1⅓ man-hours per cow to irrigate the pasture during the summer of 1929. That is labor efficiency and, furthermore, there was no hard labor involved at any time for the land was prepared for irrigation before seeding. However, it is very easy to make a complete failure of the whole proposition of irrigation by getting started with wrong equipment, distribution system and crop selection.

Irrigation of Hops

The irrigation of hops in the Willamette Valley was checked in 1924-26 in co-operation with leading hop growers and found to be a profitable enterprise. In 1925 records were kept on the Horst ranch near Salem and a 77-acre irrigated field averaged 625 lb. more dried hops per acre than the 183-acre unirrigated field. At 20 cents per lb. this amounts to $125, and deducting the total irrigation cost of $30 left a net return of $94.12 per acre.

On the entire 330 acres of the Livesley hop ranch near Salem the net profit per acre was $13.90 in 1924 and $28.80 per acre in 1925, after charging off more than $5,000 each year for irrigation costs. Both the Livesley and Horst hop ranches have installed extensive irrigation equipment, which indicates their belief in the value of irrigation.

Irrigation of Vegetable Crops

(Note: These results reported by A. G. B. Bouquet, professor of vegetable gardening, comprise the record of two years of co-operative investigation with our committee.)

Equipment, Land, Irrigation System—A 1½-in. centrifugal pump direct-connected to a 3 hp., 1,800 r.p.m., ball-bearing motor is located in a dug well at a depth of about eight feet below the ground surface. Both pump and motor are removed at the end of the irrigation season. Water is supplied by two inter-connected 3-in. driven wells, the pipe extending from 22 to 24 feet beneath the surface. Water is piped in 3-in. pipe from the pump 200 ft. to an open ditch for gravity irrigation and is connected directly to the sprinkling lines for overhead irrigation. The plant has been very effective both for gravity and sprinkler irrigation, and by adjusting the discharge valves it has been possible to operate both systems simultaneously.

Approximately three acres of sandy, river bottom soil was irrigated.

Power Used in 1927—

May 20 to June 20	$3.00
June 20 to July 22	3.41
July 22 to Aug. 20	5.07
Aug. 20 to Sept. 22	3.00
	$14.48

Crops Irrigated and Returns—

Sweet Corn (Figures for 1 acre)		
Irrigated, gross value	$164.00	
Unirrigated, gross value	63.00	
Gross increase		$101.00
Electricity used	$ 7.35	
Labor	14.65	
Total	22.00	
Net increase		$79.00
Late Cabbage. (Figures for 1 acre)		
Irrigated, 14 tons at $30	$280.00	
Unirrigated, 8 tons at $30	160.00	
Gross increase		$120.00
Electricity used	$ 8.80	
Labor irrigating	9.70	
Total	18.50	
Net increase		$101.50
Hubbard squash. (Figures for 1 acre)		
Irrigated, 10 tons at $30	$300.00	
Unirrigated, 6 tons at $30	180.00	
Gross increase		$120.00
Electricity used	$ 2.50	
Labor irrigating (uneven)	12.80	
Total	15.30	
Net increase		$104.70

Peppers.

No weighings of fruit were made, but increases from overhead irrigated areas were very marked.

Miscellaneous Data—

Electricity cost for providing one acre-inch of water at from 25 to 35 lb. pressure for the Skinner system was from 65 to 70 cents.

The number of irrigations needed varies with the crop, but the average will be from four to six per season.

Effect of water on grade of crop:

Late cabbage	Ave. Wt. Heads	Total Leaf Growth
Irrigated	5.6 lb.	4.5 lb.
Not irrigated	3.5 lb.	2.6 lb.

Two crops per season on land watered with overhead system—1928.

1st Crop	2nd Crop
Early cabbage	Spinach
Spinach	Peppers
Head lettuce	Cauliflower

Sweet Corn Irrigated—1926. (Figures for 1 acre)

Irrigated—1,230 doz. at 15c	$184.50	
Not irrigated—585 doz. at 15c	86.75	
Gross increase		$97.75
Electricity use, 25 kw.-hr.	$ 1.37	
Labor, 28 hr.	11.20	
Total	12.57	
Net increase		$85.18

Children's Farm Home Irrigation—1927.

Six-tenths of an acre of tomatoes on Willamette Valley clay loam soil was irrigated twice with a total application of ten acre-inches of water per acre.

Irrigated—9,780 lb.	$203.55	
Not irrigated—5,580 lb.	116.70	
Gross increase		$86.85
Cost—Int. on investment	$ 10.00	
47 hr. labor at 35c	16.45	
Power 105.2 kw.-hr. at 3c	3.16	
Depreciation	5.00	
Total	34.61	
Net return		$52.24

Electricity in Dairying

Application of electricity to the dairy farm offers several opportunities for the use of motor power and heat.

Motor Uses—

Grain grinding—hammer mill or burr mill, 3 or 5 hp.

Feed mixing—500-lb. batch mixer, 1 hp.

Silo filling—13 to 16-in. ensilage cutter, 5 or 7½ hp.

Hay chopping—13 to 16-in. hay-ensilage cutter, 5 or 7½ hp.

Hay hoisting—one-man hay hoist, 3 or 5 hp.

Root cutting—depending on size of cutter, 1 to 3 hp.

Refrigeration—from the chest-type box to walk-in room, ½ to 3 hp.

Milking machine—1 to 2 hp.

Heat—

Water heating—from 500 watts to 5 kw.

Sterilizing utensils—3 to 5 kw.

Of the motor uses, silo filling and hay chopping with a 5-hp. motor will be most difficult to satisfy the average farmer. It will require a man who keeps his ensilage cutter properly adjusted and changes knives twice daily. It requires proper speed of the blower. It requires a good belt or bearing troubles will occur. We will use a V-belt next year, which I believe is the farm belt of the future.

Water heating and sterilizing in Oregon is not a problem of whether or not it can be done, but what wattages should be used under the varying conditions to give satisfactory service at a minimum cost for power. This involves a rate schedule. Water heating and sterilizing cannot be separated. That is, both must be done with electricity efficiently and at a cost that will meet competition, or neither. The only type of hot water service that a dairyman is justified in installing if he has water under pressure is a domestic hot water tank and not a type that requires dipping the hot water from a sterilizer and carrying it to the sink. It may be possible to "get by" with an electric sterilizer for a water heater at present, but it should be one that will merit its use as a sterilizer when a modern hot water tank and electric heater is installed later as finances permit.

One of our major projects has been dairy refrigeration. Our cream refrigeration project has been based on the market demand for high-grade butter which requires a good quality sweet cream. At least half of the creameries of western Oregon are paying a premium of 3 cents per lb. of butterfat for sweet cream free from objectionable flavors. A good cow will produce 1 lb. of butterfat per day. If this cream is sold as No. 1 sweet cream it can be made to return 3 cents more per pound of butterfat than if sold at the next lower grade. Frequent delivery or electric refrigeration with delivery twice a week with reasonable sanitation will permit the sale of No. 1 sweet cream.

From our studies it has been found that it will cost from 25 to 35 cents per day for power, interest, and depreciation for a chest-type dairy refrigerator which can be installed for about $500. This will take all of the 3-cent premium from 9 to 12 cows to break even. A larger herd should return a profit. If the sweet cream is sold for restaurant use or ice cream, it should bring a premium of from 5 to 10 cents per pound.

We have conducted experiments to determine the performance of the chest-type dairy refrigerator for milk cooling and believe it meets the requirements of the dairyman who handles his milk in cans, but does not bottle his milk. By using an agitator, 10 gal. of milk can be cooled to 50 deg. in 45 minutes by placing the can in the chest of refrigerated water.

The dairyman who bottles his milk on the farm will find the chest-type refrigerator unsatisfactory. He should use a large reach-in box or walk-in room with sufficient brine for cooling the milk from 70 to 45 deg. by using a surface cooler through which the brine is circulated. Tap water can be used to cool from 95 deg. to 65 or 70 deg. in the upper compartment of the surface cooler. This type of equipment will cost from $1,000 to $1,500.

The biggest problem just now is to get the refrigerator company representatives to select the right equipment for the job and neither over-sell nor under-sell the job.

Electricity on Poultry Farms

The application of electricity to the poultry farm has been given considerable attention. Three bulletins have been issued up to the present time:

Station Bulletin 231—Electric Lights for Increasing Egg Production.

Station Circular 81—Electric Water Heaters for Poultry.

Station Circular 88—Motor Driven Green Feed Chopper.

A bulletin on electric brooders will be published soon.

Electric brooder experiments began in 1926, but results have been delayed by various interferences. In our tests we found that with a rate of 30 cents per kw.-hr. the electric power cost was slightly less for electric brooding than the fuel cost for coal brooders when brooding in units of 400 or 500 chicks. Electric brooders require less labor than coal-stove brooders and do not give the trouble of over-heating or the fire going out when warm weather is experienced during the brooding season.

We have had power interruptions of two hours on two occasions and had no difficulty in maintaining brooding temperatures by closing down the ventilation and putting all chicks under the hover. In one case it was on the second day of brooding and the other was on the sixth day with the outside temperature at 23 deg. F. The operator must be on the job to attend to the chicks during power interruptions. The "safety first" method calls for the use of a power-off alarm.

I believe that, in general, electric brooder manufacturers are over-rating their brooders. Good poultrymen will learn by experience if not by any other means that at least 7 sq.in. per chick is needed.

I would consider electric brooding very good as a load builder even though the season is short, beginning about March 15 and extending to June 1 for chicks. Brooding of turkeys would extend to July 1. Each brooder will bring a revenue of from $1 to $2 per month of operation with little or no change in equipment for service since each brooder has a demand of 500 to 1,000 watts.

Feed grinders and mechanical feed mixers have a place on many poultry farms. A set-up that is giving very satisfactory service on the college poultry farm consists of a 3-hp. motor which drives a burr mill, which drives a 300-lb. batch feed mixer, which drives a sacking elevator. This is a typical farm set-up for a one-story feed room which does not permit the use of overhead bins. In 50 minutes this equipment mixed 1,550 lb. of pullet mash of eight ingredients and ground the 500 lb. of corn used in the mix. In the following 35 minutes, 1,400 lb. of corn and wheat were mixed and sacked. The two jobs required 3.4 kw.-hr. This 3-hp. motor is used on a combination rate permitting up to 3 hp. in motors to be metered with the electric range.

Since there are now available at least two good electric water heaters for poultry, there is no reason why every utility having poultry producers in its territory should not be actively engaged in seeing that this equipment is available to the poultrymen and that publicity is given to value of this service. Heaters of from 100 to 150 watts are required for laying houses, and heaters as low as 50 or 75 watts are desirable for small containers.

Hay Hoists

We have issued Station Bulletin 255 on "Electric Hay Hoists." Perhaps this should be titled "The One Man Electric Hay Hoist," for there is a particular difference between our hay hoists and all hay hoists we have been able to find on the market.

At 3 cents per kw.-hr. it costs only 1 cent per ton to hoist hay, so the power companies will not draw much revenue from a hay hoist. However, it is another use for a utility motor of 3 to 5 hp. From the farmer's standpoint, it eliminates one man and a team at haying time.

The only difficulty at the present time is that there is no satisfactory single-lever hoist on the market at a price of from $80 to $100, which is the price that our friction hoist can be sold for. Nobody is going to make a lot of money on such a proposition, but I believe the utilities should start this off by financing the construction of 30 or 40 hoists to be made up at once so that we can tell farmers where they can get a hoist such as the one we are using at the college and which is described in our bulletin. Furthermore, they can then be demonstrated at country fairs, as we have done at the Oregon State Fair the past two years.

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*What Electric Service Means to Agriculture**

As Viewed by the Agricultural College

By Hobart Beresford

INTEREST of the college of agriculture of the University of Idaho was focused first directly on "what electric service means to agriculture" in 1925, when the Idaho State Committee on the Relation of Electricity to Agriculture was first organized. Upon investigation, the executive committee found that it would be unnecessary to build special rural test lines as had been the case in many states, because one of the distinguishing characteristics of agriculture in Idaho at that time was the use of central station electric service on the farm. This relatively wide distribution was made possible largely by the irrigation pumping load that had pioneered the way for 1,259 miles of rural distribution line serving 7,006 rural customers.

Resume of Farm Conditions

It has been the intention of the college of agriculture to co-operate with the Idaho Committee on the Relation of Electricity to Agriculture in an endeavor to find the facts relative to the beneficial use of electricity for the development of the agricuitural industry of the state. The first investigation sponsored by this group was the study of the use of electricity on Idaho farms at that time. It is the data reported by this study that gives the basis for the measure of progress made in electrifying Idaho farms.

Approximately 60 per cent of the tillable land in the state is irrigated, and the use of electric power for irrigation pumping has made it feasible to extend transmission lines. The size of the irrigated farm usually runs from 40 to 80 acres, the average in Canyon County being 68 acres, of which 47 acres were crop land. (Farm Census. United States Department of Commerce, Washington, D. C., 1925.) The average size of farm for the state is 200 acres, while in the dry-farm areas the farms may be 500 acres or more as shown by the average of 528 acres in Camus County. The number of farms per mile per distribution line has been an important factor in making possible the extension of rural electric service. During the last five years the number of rural customers in Idaho has been doubled, giving slightly more than 14,000 rural customers, as of Jan. 1, 1930. This rapid extension of electric service to the farms of the state and the interest of the agricultural experiment station in the Idaho rural electrification project at Caldwell, gives the basis for "What Electric Service Means to Agriculture."

Irrigation and Drainage

Irrigation continues to be one of the main reasons for extending rural lines. However, in many of our irrigated areas the continual application of irrigation water has developed serious drainage problems, which offer a new opportunity for the use of electricity, for pumping wells for both irrigation and drainage. Although the development thus far in this field has been confined to the Boise Valley a study made this past year on six pumping plants used for this purpose indicates that in the near future drainage pumping will be an important part of our rural electrification program.

Dairying

Electric service in agriculture has helped in putting dairying on a firmer basis. In my opinion the real reason why farmers sell off their dairy herds just as soon as they get the mortgage paid off, is that they do not like to do the milking any better than the rest of us. Much of the hard work connected with dairying can be eliminated by the use of electrically operated equipment. Tests at Caldwell show that the milking machine alone saves 53½ man-hours of labor per cow per year. As one farmer expressed it, "It is true that the milking machine saves some labor, but the important thing is—it saves the time that allows me to irrigate in the morning when I should." I take care of

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my 20 cows without much more work than I used to have with seven." The thought hinted at in this quotation promises the greatest possibility for the future of electric service in agriculture, namely the increased capacity and hence increased income for the individual worker and a more desirable distribution of labor. Time saving and labor distribution is not the only advantage of electricity in the dairy. Field tests conducted by the dairy department have shown that motor operated cream separators actually save their owners money by putting more cream in the can, due to the efficient operation of the separator when the electric motor is used for power.

Farm Motors

The use of the portable farm motor is becoming more popular and promises possibilities of mechanizing the small farm on such jobs as feed grinding, hay hoisting, silo filling, etc., to the extent that our small farm units may compete on an equal basis with the large scale farms where mass production is practiced by the use of field power and machinery that as yet remains unadapted to the 40-acre units. The 5-hp. motor is doing its share to replace the horses in the state which are decreasing at an average rate of 10,000 head per year for the last ten years. (The Annual Livestock Inventory, Jan. 1, 1930. United States Department of Agriculture, division of crop and livestock estimates.) Teams are vanishing from the old sweep feed mills and electrically operated hay hoists do away with both the derrick team and driver.

When electric motors are used for filling silos the tractor is kept in the field and the size of the crew reduced so that fewer teams are required and a better distribution of labor obtained. On the whole what the college of agriculture thinks of electric service in agriculture must necessarily be a reflection of what we hear from the farmers themselves, and in the case of feed grinding one of the best farmers in the Boise Valley says, "Feed grinding on the farm is a great convenience, and my 3-hp. electric motor furnishes ideal power for the job."

Poultry

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Living Conditions

The aggressive rural electric program that has been sponsored in Idaho has done more to improve rural living conditions than any other single activity. When electric service is available there is a real incentive to install a water system, which is usually followed by modern plumbing, and a general improvement of living conditions, which eliminates much of the drudgery for the farmwife. The electric washing machine, iron, range, refrigerator, vacuum cleaner, save hours of labor and gives the farmer's wife more time to spend in making the farm home more attractive and livable.

Greatest of all the values of electric service in agriculture is the influence on the farmer himself. As our rural lines are extended we find the improvement of living conditions attracting better farmers to our state, and agriculture like all other industries is dependent for its advance, not upon the power, and machinery, or the crops, lands and livestock, but upon the men and women engaged in the industry.

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*Value of Executive Demand in Building Rural Load**

By J. C. Scott

I CANNOT hazard a guess as to what many of the old and experienced men of the electric light and power industry will think of me for being so liberal with suggestions of what they can do to develop and increase farm business. Yet, since I have been given this subject I promise to be honest with reference to my own convictions. I realize that men who have the responsibility of leading this great industry have many obligations that I know nothing about, and that if I had all the information they have, together with their good judgment, I would probably do as they do, or not as well. But it is because in my position I see things in a different light and from viewpoints which they may not have that I make these suggestions.

I am convinced that, if we are to make a first-class job of farm electrification, we must give the farmers the kind of service they want. We may think we are giving just the kind of service that we would want if we were in their place, but are we? And, if we are not, what can the executives do about it?

Concerning the kind of service farmers want, permit me to relate the experience of A. R. Hamerquist, local manager for the Puget Sound Power & Light Company at Stanwood and adjacent territory, which is a small district in northwest Washington devoted to general farming.

Motor Sales Most Efficient

When Mr. Hamerquist was put in charge of the Stanwood territory he outlined for himself and very successfully carried out a farm electrification program which differs in some respects from the practices of most power companies. He helped farmers to do their general farm work with electricity to the extent of putting 91 motors on farms in his small territory in one year. Here is what he says about the farm motor business:

> In spite of two rate reductions our revenue for the Stanwood office shows a gradual increase over last year. Our load curve has stayed nearly up to normal during the past summer, where it generally drops considerably at that time of year. Putting electric motors on our farm lines has had more to do with our increased revenue and getting a better load factor than anything else. The load factor on many farms has been increased from a bare 10 per cent to 30 per cent, due to the installation of motors and machines to do farm work.
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> Motors generally are easier to sell to farmers than ranges. They make a better introduction to a first call on the farmer. He will listen to a talk on motors where he will not on ranges. The sale of a motor makes a friend and leads to the sale of a range and other household equipment. We have sold many motors to farmers whose wives later came into the office and bought ranges unsolicited. This office got first

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place in the last range campaign in this district, and we did little soliciting.

Selling motors to farmers and giving service in helping to get the motors properly connected, has sold securities for us as well as ranges. Some of the farmers who used to be our worst knockers are now buying our stock and advising their friends to cut out some of the hard work and use a motor. The change came about because we sold them motors and then made the motor work satisfactorily.

In many instances farmers "got sore" at the company because motors that they bought from dealers won't work satisfactorily. They blame it entirely on the company, while it is probably because of too small wire leading to the motor. Sometimes the farmer puts a larger motor on his line than his transformer will handle. In any case, we fix the difficulty at once or show him definitely and simply what the trouble is, so he can fix it.

Selling motors is a matter of giving service with the motor. It is necessary to work with the service department and see that the wires and transformers are right before the motor is ever turned on. Because this service is necessary the selling of motors is absolutely a power company activity.

Advertise to the farmers that the power company men are ready to give this service on motors, and see that each farmer gets the literature and advertising material that he should be interested in.

Always work motors on extensions, as it is easier to get revenue in this way than is generally supposed. If the farmer cannot afford an automatic pumping outfit, get him to put a motor on his pump jack. As soon as he can afford an automatic outfit he will take the motor off the pump jack and use it for feed cutters or other uses.

Motors should be sold to farmers just like ranges and washing machines are sold. I have repeatedly gone onto farms where gas engines were used and got the farmer to let me install an electric motor in its place on trial. I see that the moter works right and the result is not only a motor sale but more friendly feeling toward the company.

I would venutre to state that in a very few years we will look back and wonder why we were so slow in our methods in attempting to build up the load on existing lines and bring the factor load of individual customers up to a point where investment and revenue ratio no longer are strangers.

Executive Demand Needed

You may say, "If this motor business is such a good thing, why don't more men carry out a similar program?"

The answer is simply this: All worth-while developments must have a small start and grow, rather than jump, toward perfection or completion. Farm electrification as carried on at present by the utilities started, and is making rapid growth, in the home. The entire sales force of each company is doing a splendid job in carrying out the policy outlined by their executives. All men want to please those to whom they are responsible, and very few care to take the personal responsibility of enlarging on the program outlined for them.

In other words, the sales promotion set-up of most utilities does not at present include load-building devices outside the farm home. Consequently, it is only natural that when farmers come to us for information about doing their farm work by electric methods requiring apparatus which we do not merchandise, they do not get the same service attention and encouragement as they do when interested in electric farm practices which might result in a sale of merchandise.

The setting up of quotas and competitive selling has proved successful in home electrification, but home electrification is not complete farm electrification. Farmers are becoming interested and want information concerning electric apparatus and service with which they can satisfactorily pump water, cut and grind feed, fill silos, hoist hay, milk cows, heat water (for chickens and cows and for washing dairy utensils); light, brood and incubate chickens, operate a hotbed, burn stumps, spray orchards, and do many other things.

Proper Organization Needed

Such a farm electrification program does not necessarily mean the hiring of an additional force of men. Nor does it mean that the power companies should actually sell all electrical farm apparatus. It does mean, however, that the utilities arrange their set-ups so their men will have more incentive to build up the farm load. That is, employees should be given recognition in some way, so that they will feel it is their job actively to encourage farmers to use electricity in every possible way, regardless of whether they sell the apparatus or help the farmers to get it from some one else. And then see that his electric service, including transformer, wiring, rates, etc., fit the job.

To illustrate this point, let us consider the farmer who might inquire at a utility office for a motor to do farm chores. Suppose the power company does not handle motors. The farmer gets such meager information that he buys a gas engine. Or, he may go to a dealer, get a 5-hp. motor, connect it to his light meter with 500 ft. of No. 14 wire, and perhaps off a 1½-kw. transformer, thereby causing him enough trouble to breed an unnecessary amount of ill will against the company. In any event, either situation is undesirable from the standpoint of the utility company attempting to build farm load.

A farm electrification program properly planned will make it the responsibility of the employees of the utility to see that farmers get complete service and information so they can do their work with electricity. While this idea is carried out in many respects by all companies, yet there is much farm apparatus coming into use to which little attention is given by the utilities.

All executives realize that the real goal toward which their companies are working is profitable load building by electric service in a way satisfactory to their customers. Merchandising is a very important means to this end. However, executives often bear down on merchandising certain load-building devices until the employees feel that the sale of this particular apparatus is the final objective. Such a condition often causes much lack of interest in other load-building devices, resulting in dissatisfied customers.

Utility service should include more careful attention to working up line extensions with farmers who want service. A lack of correct information about how line extensions are financed and built leads to much misunderstanding among farmers and militates against load building. Many more farmers will be enjoying electric service, when the utilities have a better understanding of the possible load on farms, and when the farmers have more complete knowledge of how they can get electric service. Executives should consider the advisability of instalment payments for prepaid revenue. It is being done in the Middle West with success.

Closer Contact With Field Men Advocated

Power company executives should take time from other duties to mingle more with that part of their personnel that represents their companies to the public. Also they should mingle more with the public. Two needed improvements would result. First, there would be instilled in the employees a more personal feeling toward their company and a better understanding of the high ideals concerning service to the public, which should make possible the elimination of many rigid rules. Second, it would give the executive a better understanding of how his company's service affects the public, and thereby help him to form company policies that will bring about an improved feeling on the part of the public.

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Utility service should include more careful attention to working up line extensions with farmers who want service. A lack of correct information about how line extensions are financed and built leads to much misunderstanding among farmers and militates against load building. Many more farmers will be enjoying electric service, when the utilities have a better understanding of the possible load on farms, and when the farmers have more complete knowledge of how they can get electric service. Executives should consider the advisability of instalment payments for prepaid revenue. It is being done in the Middle West with success.

Closer Contact With Field Men Advocated

Power company executives should take time from other duties to mingle more with that part of their personnel that represents their companies to the public. Also they should mingle more with the public. Two needed improvements would result. First, there would be instilled in the employees a more personal feeling toward their company and a better understanding of the high ideals concerning service to the public, which should make possible the elimination of many rigid rules. Second, it would give the executive a better understanding of how his company's service affects the public, and thereby help him to form company policies that will bring about an improved feeling on the part of the public.

By simply adding a public relations department or a farm service department to a company does not solve the problem. These departments have a very important work to do, but they cannot reach all customers with better public relations ideas and improved farm practices except through the help and co-operation of the company as a whole.

Misunderstandings by farmers might be prevented if the power companies would confer with one another before making radical changes in policies and rates. Farmers of different sections compare their service and rates, and while it is impossible to make all conditions of service and rates similar for different sections, yet much can be accomplished along this line. Bear in mind that satisfactory relations with farmers have much to do with their load building.

Nothing is said about rate reduction in this paper, because there are many other improvements of much more importance which should be put into practice before rates are reduced again. However, there should be a one-meter rate, with one minimum or fixed charge applicable to most farms, under say a 10-kw. demand (not connected load), encouraging, instead of discouraging, farmers to buy apparatus and machines to do numerous jobs without having to pay minimums on several meters or on connected hp. The nature of farm operation is irregular. One electric use is in operation only a short time during the day, or at best for short seasons of the year. A desirable farm load can be built up by developing and encouraging numerous uses.

Summary

In conclusion, the following is a brief statement of how utility executives might co-operate in building farm load:

1. Arrange a set-up so all employees connected with the sales department will get recognition and feel it their job to give proper assistance and encourage farmers to do any and everything possible with electricity. Quotas should be on a basis of kw.-hr. consumed.
2. See that farmers get a better understanding of the basis on which line extensions are built.
3. Get closer to the company personnel and to the public, by personal contact.
4. More intra-company conferences on vital issues, policies, rates, etc., affecting the public.
5. Put into effect a one-meter rate affecting all farm uses up to a certain demand.

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*Developing a Local Organization for Farm Load Building and Rural Extension**

By W. M. Hamilton

THE chairman of the rural electric service committee, in assigning this topic to me for discussion requested that as far as practical I confine the discussion to actual experience, and specific suggestions. His idea is to bring out in the general discussion the experience of others so that all of us in attendance may benefit therefrom.

We all realize that is it impractical to develop and set forth a formula, or set of rules, for "developing a local organization for rural extensions and farm load building," that will fit and apply to all local conditions and requirements.

Probably it is equally, if not more difficult, to standardize this activity than any other in the central station business at this time.

The following major factors will control and govern the development of such an organization in proportion to their relative weight of importance in each case:

1. Number of existing farm customers in the district.
2. Number of farms in the district not being supplied with service.
3. Character, or kind of farms predominating in the district.
4. Political expediency.
5. Personnel available for this work.

Personnel, although mentioned last, is by no means the least important factor controlling the set-up of the local organization.

There appears to be in the Northwest territory two rather distinct and well defined ideas and policies as to the development of farm load. As in many other activities, both of these ideas, although quite different, are deemed quite efficient in producing the desired result. It is quite possible that the divergence between the ideas in the respective districts is due to the divergence, between the factors above mentioned, controlling the nature of the organization and methods pursued by it in the development of the load.

The two different ideas and policies are exemplified by the practices and methods in the Puget Sound territory on one hand, and those being undertaken and advocated in Oregon by the Oregon State Agricultural College, and most of the power companies. These two districts have approached the problem from different angles being motivated in the development of farm load very largely by divergent factors. These factors are not within the scope of this discussion but should be investigated, understood, and considered in developing local organizations for farm load building.

Believing that the factors mentioned in the Willamette Valley Division of the Pacific Northwest Public Service Company were rather a combination of the factors which motivated the Puget Sound company in the adoption of its policies and those which are behind the policies advocated by the Oregon college and companies, we have endeavored to employ those parts of both plans which seem to best meet our local requirements.

Conditions in Willamette Valley

There are about 13,000 customers in the division, about ten per cent of which are rural and farm customers. About sixty per cent of the main roads radiating out from the cities and towns in the division have rural distribution lines upon them. About forty per cent of the crossroads in the vicinity of the same cities and towns are also being served.

We are operating under what is known as the "equity plan" as distinguished from the "annuity plan" of line extension policy. The maximum investment, or equity being carried by the farmers in these lines with a few exceptions is $150. The rate being paid by these farmers for residence service is the same as that paid for similar service in Portland, Salem, and other cities and towns of the system plus a delivery charge to cover the additional cost of rural service not in excess of $1.50 per month with a few exceptions. The combination of the urban rate and this delivery charge results in a combination rate that is promotional in nature and is of great assistance in building up the farm load after the extension is completed, as the average

* Supplement No. 4 to the report of the rural electric service committee.

cost per kw.-hr. drops off very rapidly with an increase in the consumption.

There is a great variety in the character and kind of farms in this territory running all the way from intensified truck gardening to mere cattle grazing land, including dairy farms, berries, tree fruits, and grain. Diversified farming in two or more of the above mentioned lines is being practiced by many farmers and is being advocated by the agricultural college.

There is considerable demand by farmers and some politicians for the extension of electric distribution lines into the rural districts not served. This extension work is going forward steadily year by year, but no record-breaking progress is being made in this line because we have refrained from making extensions that would not be self-supporting in the near future. Our idea has been to cover the territory as rapidly as practical, but not necessarily as rapidly as possible, and to build well even if necessarily slowly, believing that any business, or branch of a business, can grow successfully only on a firm and sound foundation.

Developing an Organization

With the foregoing conditions, principles, and ideas in mind as a guide, we have developed a local organization of three men in this division for the promotion of rural extensions and farm load building.

Believing that a thorough knowledge of farm conditions both from a practical and a theoretical standpoint was of major importance in developing farm load, we first employed a young man who had been raised on a farm, and had graduated from the agricultural department of the Oregon State Agricultural College. To test out this man's qualifications for the work in mind from the standpoint of ability to apply himself to the tasks assigned to him, and his ability to make friends with employees and others, he was placed in a couple of positions in the company where we could observe his qualifications. After he had demonstrated to our satisfaction that he had the proper personality and character to represent the company in its dealings with the farmers, he was assigned to rural extension work.

We next employed another young man who had been raised on a farm, and had considerable practical farm experience, although he is not an agricultural college graduate. He has also had a few years experience in the line department of a central station, and a few more years in the merchandise and security sales department of other electric power utilities. Here again we were careful to make sure, as far as possible, that he had the right qualifications in character and personality to meet and deal with the farmers successfully before putting him on the rural service work. We had an opportunity to observe his qualifications in this respect while he was in our security sales department.

The third man, although he had but little practical farm experience and was not an agricultural graduate, had considerable experience before entering our employ as a representative of other electric utilities in agricultural communities, and had specialized lately on rural electrification.

Method of Operation

Up to the present time these men have been largely engaged in the promotion of extensions. When a farmer, who is not being served, makes inquiry at the office as to the possibilities and cost of securing electric service, the inquiry is turned over to one of these men who calls on the farmer at his home. Then, either alone or with the aid of the farmer and possibly one or two neighbors, he canvasses the other residents living on the road. Having obtained an idea as to who are interested in having service, the rural service man proceeds to make up a formal working estimate of the line required to serve the farmers in question.

He then advises the customers as to what their share of the cost of the extension will be, and explains the company's policy in regard to extensions, rates, etc. He then secures their application for service under our standard contract for service involving line extensions, collects money due thereon, and stakes out the line for the line department.

From this point on, the line department proceeds with the work of installing the line, the rural service man keeping in close touch with the work so as to tell the linemen of any special conditions or requests that the farmers have made regarding the construction of the line. By so doing, he eliminates the possibility of friction between the farmers and the linemen, which might otherwise be engendered. At the same time, he also assists the farmer in having his house wired by advising him how to proceed either to do the work himself, or to contract with the wiring contractors to have it done at the most reasonable terms. After the line is installed, and the farmer's premises connected, the rural service man follows up each extension and calls the farmer's attention to the various ways in which he can make use of the service to his most economical advantage and convenience.

You can readily see that by the time the line has been completed and put into commission, the rural service man has built up quite an intimate contact with most of the farmers on the line. As proof that this is true, it is very interesting and sometimes almost amusing to note the attitude of the farmers when they come in to the office seeking information of some kind pertaining to their electric service. They ask for and want to deal with the rural service man and no one else. They will even make a trip into town at a later date to meet the rural service man if they cannot find him in on the first call. It is a well known fact that the average farmer does not like to do business with a stranger if he can avoid it, and for the time being at least, all employees in the "soul-less" corporation are strangers to him except the rural service man.

We therefore recommend that these rural service men be local men attached to the local office of the company, and handle all phases of the promotion of the line extensions, as outlined above. Such a rural service man is in a much more favorable position to advise the farmer regarding the installation of electrical equipment after the line is completed than would be a representative from the central office of the company who would be a stranger to the farmer. People who have not had the opportunity to study first-hand this psychological characteristic of the average farmer will not appreciate what weight should be given to this phase of the matter in considering a local organization for developing farm load.

Intensive Solicitation Delayed Till Later

No intensive solicitation is made immediately following the completion of a line extension in an effort to induce the customer to buy additional equipment at that time, as we have found from experience that the customer is not in a receptive mood to consider such a proposition at that time, due to having invested considerable money in the wiring of his premises, and purchasing such equipment as he already wanted and needed.

The development of farm load through the medium

of various kinds of printed matter, demonstrations, lectures, fair exhibits, etc., can be most advantageously handled, we believe, by a rural service publicity man operating in or out of the main office of the company, with the aid of the local rural service men in the various districts.

After we have covered our territory more thoroughly with distribution lines, we propose to devote more and more of the rural service man's time to the development of the load on the existing lines. By that time, the farmers will have had the service long enough to have become accustomed to the advantages of the electric lighting, domestic water pumping, etc., and will have had time to recover, so to speak, from the expense of installing the electrical service, and will be in a position to consider the extension of the use of the service, both domestically and industrially in their farm work.

In the meantime, we are sending to all whom we believe will be good prospects, the little magazine entitled, "Electricity on the Farm," and other literature from time to time, thereby sowing the seeds of desire for additional electrical equipment, and paving the way for the approach of our rural service men at a later date.

Transportation Is a Problem

The question of the proper kind of transportation for these rural service men has been more or less of a problem, and there is still considerable difference of opinion between rural service men as to the best form of a car to use. We believe that it is about an even choice between the tudor sedan, or coach type of car, and the delivery type of car, with the doors in the back, which also has provision for installing additional seats readily, so that the car will carry three or more passengers. The display car, or truck, carrying samples of the various kinds of domestic appliances and water pumps has not proved to be the success that was first anticipated.

Farm Load Building Is Highly Specialized

In conclusion, it seems highly desirable to emphasize the necessity of having in at least each principal district or division office, a local organization consisting of one or more men thoroughly qualified by practical experience, education, personality, and character to carry on this specialized work of farm load building, as practically all of the other men in the electrical power business are unfamiliar with this highly specialized line of work.

Most of us who may be competent electricians and electrical engineers and public utility managers have very little knowledge of the science and practical work of agriculture, and we must therefore use the best judgment and care in the selection of our rural service men, and then depend upon them to carry on this work in a practical, efficient, and progressive manner.

Engineering Section Report[1]

ACTIVITIES of the Engineering Section have been carried on by its executive committee and nine standing committees. These standing committees do their work largely through correspondence. On a few occasions, however, some of the committees have held meetings. The executive committee has held several meetings during the past year.

The seventh annual general meeting of the section was held March 26-28 in Aberdeen, Wash. Each of the standing committees presented a portion of the program which, to a certain extent, was a summary of its work during the year. The transactions of this general meeting will be published in book form, copies of which may be obtained by those interested in the subjects discussed. These subjects will be listed further on in this report.

Contact With National Engineering Section

There has been a marked improvement in the cooperation of geographic committees with the corresponding national committees. This has been brought about by the appointment of a geographic contact man in each of the national committees. This person, who is a vice-chairman, is assigned the duty of co-ordinating the activities of the geographic committee with the national committee.

Three delegates were sent to the first group meeting of the Engineering National Section held in Pittsburgh, Pa., Sept. 30 to Oct. 3, 1929. Four representatives were sent to the second group meeting which convened in Chicago, March 10-13, 1930.

Special Assignments From the National Section

The Engineering Section of the Northwest Electric Light and Power Association was fortunate in receiving financial aid from the national Section in carrying on studies of two problems. One of these is radio interference from high voltage insulators and its mitigation. This study is being made by the inductive coordination committee working in connection with the electrical engineering department at the Oregon State College, Corvallis, where a special high-voltage line has been constructed. The tests are under the direction of Prof. F. O. McMillan.

The second problem to which the national Section has given aid is that of fishways and control of the movements of migratory fish by means of the "electric screen." This work is being directed by the hydraulic power committee and its subcommittee on fishways.

Committee Activities

Underground Systems Committee, C. H. Hoge, Chairman—

Local problems rather than those outlined by the national committee were made the objects of study during the year by the underground systems committee, one of which was on non-metallic sheathed cable for secondary and service mains. Discussion by the committee members brought out that some of the advantages in using non-leaded cables were the elimination of sheath currents and electrolysis, cheaper first cost, and lower cost of splicing. Advantages of lead-sheathed cables were found to be the possibility of lower maintenance costs and waterproof quality. Several companies have purchased non-leaded cable for street-

[1] Executive Committee: D. W. Proebstel, chairman; E. F. Pearson, vice-chairman; J. B. Brokaw, S. B. Clark, H. H. Cochrane, E. H. Collins, J. B. Fisken, J. A. Hale, W. S. Hill, C. H. Hoge, A. H. Kreul, O. L. LeFever, Z. E. Merrill, T. A. Purton, G. E. Quinan, H. H. Schoolfield, C. C. Simeral, J. C. Thompson, M. V. Watson, J. E. Yates.

lighting and low-voltage mains and several others contemplate using it in the near future.

The committee continued its study of the construction and operating features of a.c. network installations, paying particular attention to the use of a higher voltage for primary distribution. Another subject discussed was the effect of sheath currents on the accuracy of current readings in large single-conductor cables, when taken with split-core current transformers. It was the consensus of opinion that, although sheath currents are a factor, ranging from 25 to 100 per cent of conductor current when lead cables are heavily loaded, it was not a serious problem as it always is possible to strip back the lead if accurate readings are desired.

At the annual general meeting of the Engineering Section, the underground systems committee presented two papers, "Construction and Maintenance of Ornamental Series Incandescent Street Lighting Systems" by G. L. Walker, Pacific Northwest Public Service Company, and "A Network in the Embryo" by Paul P. Ashworth and A. C. Kelm of the Utah Power and Light Company. Mr. Walker's paper described the practices of his company in installing ornamental street lighting systems, drawing particular attention to the erection of standards, cable installation, construction of vaults, and maintenance of equipment. Mr. Ashworth's and Mr. Kelm's paper described the 4,000-volt a.c. underground distribution system in use in the down town district of Salt Lake City and also a plan of future development of the system to take care of increased load.

Electrical Apparatus Committee, E. F. Pearson, Chairman—

The work of the apparatus committee for the past year has been devoted to the following subjects:

1. A review of the entire subject of system stability and ways and means of securing and improving stability on existing systems. This study was summarized in a report presented at the Aberdeen meeting by Richard McKay, and C. E. Cannon, of The Washington Water Power Company.

2. Economics of circuit breakers and obsolesence problems were dealt with, and this study was summarized in a progress report by Joe Hellenthal, Puget Sound Power & Light Company. In connection with this study, considerable data were obtained relative to the substitution of different types of fuse cutouts for circuit breakers in rural substations.

3. A review of the subject of excitation methods for synchronous machines was summarized in a progress report by John Bankus, Pacific Northwest Public Service Company.

Hydraulic Power Committee, E. H. Collins, Chairman—

This committee presented papers on the following subjects at the general meeting:

1. Repairing Water Wheel Runners, by G. C. Sears, Puget Sound Power & Light Company.

2. Progress Report on Fishways, by J. E. Yates, Pacific Power and Light Company.

3. Presentation of Data Relative to Automatic Plants, by J. A. Hale, Utah Power and Light Company.

Overhead Systems Committee, T. A. Purton, Chairman—

The overhead systems committee has devoted considerable effort to the study of high-voltage grounding. These features were covered by three papers presented at the general meeting:

1. The Maintenance of High-Voltage Lines by the Use of Hot-Line Tools, by Walter Smith, Mountain States Power Company.

2. Distribution System Grounding, by Clarence Boggs, Idaho Power Company.

3. The Zinc Meta-Arsenite Method of Pole Treatment, by D. R. Manual, Curtin-Howe Corporation, Spokane, Wash.

Meter Committee, A. H. Kreul, Chairman—

The meter committee investigated and reported on the following subjects through subcommittees for the year 1929-1930. This committee has co-operated closely with the national committee.

1. Survey of Safety First for Metermen During 1929. This survey showed that safety work and first aid among metermen was becoming more popular and better organized. Eleven companies, employing 131 metermen, reported ten accidents during the year. The previous five-year average was about fifteen accidents per year.

2. Education of Metermen. Fourteen meter men among ten companies have taken the N.E.L.A. Metermen's Course and the indications point to a larger number during the coming year.

3. Comparative Value of Natural and Synthetic Jewels. Two companies out of ten report the use of synthetic jewels as a cheaper substitute for sapphire jewels in meters. The question of the life of the synthetic jewel has prompted an investigation, to be made during the coming year, through a series of tests of the accuracy of the meter at different periods of the life of this type of jewel.

4. Overloading Old Type Meters. Operating practices were investigated among member companies to determine what was being done with old type meters with poor overload and temperature characteristics. At present very little attention is being given to such meters which still are in service, but the question of changing them to newer types was thought worthy of close investigation. One company reported that a test on several meters having a heavy consumption showed the loss in revenue to be slightly greater than 0.5 per cent. The results showed that 5-amp. meters were fairly accurate on installations using up to 200 kw.-hr. per month.

5. Depreciation and Obsolesence of Meters. The average life of meters as reported by eleven companies is as follows:

Single-phase meters	20 years
Three-phase meters	20 years
D.c. meters	15 years

This life was estimated on meters manufactured prior to 1925. Since that time, the new type meters have had five years added to their life.

Two very interesting subjects were presented at the general meeting. They were:

1. Demonstration of Stroboscopic Meter Testing, by J. E. Bridges, Westinghouse Electric and Manufacturing Company.

2. Demand Meter Developments, by L. H. Kistler, Northwestern Electric Company.

Inductive Co-ordination Committee, H. H. Schoolfield, Chairman—

This committee has been very active along several lines, one in particular being the investigation of radio

interference now under way at the Oregon State College.

The following papers were presented at the general meeting:

1. Trend of Inductive Relations Between Power and Communication Utilities, by R. W. Mastick, The Pacific Telephone & Telegraph Company.

2. Elimination of Radio Interference Caused by High-Tension Insulators (Progress Report on Experimental Work at Oregon State College), by Prof. F. O. McMillan.

3. Radio Interference From Distribution Transformers, by T. W. McLean, The Washington Water Power Company.

Accident Prevention Committee, John B. Fisken, Chairman—

A great deal of effort has been exerted in establishing and maintaining better and safer working conditions, both in construction and operation. The chairman was instrumental in securing the award of two Insull Medals, one of which has been presented.

The following program was presented at the general meeting:

1. Low-Voltage Hazards, by G. I. Drennan, Pacific Power & Light Company.

2. The Use and Care of Rubber Protective Devices, by Jas. B. Brokaw, Eastern Oregon Light & Power Company.

Prime Movers Committee, C. C. Simeral, Chairman—

During the last year the prime movers committee devoted its efforts to the study of local problems and prepared two papers for presentation at the spring meeting. They were presented as a symposium covering the modern trend in the design of steam boilers:

(*a*) Boilers, by W. H. Beecher, Chas. C. Moore & Company.

(*b*) Turbines, by J. E. Yates, Pacific Power & Light Company.

Public Relations Section Reports[1]

THE Public Relations Section of the Northwest Electric Light and Power Association was organized early in the association year, and the following committees were appointed and are now functioning:

Advertising and Publicity Committee; chairman: W. P. Strandborg, Pacific Northwest Public Service Company, Portland, Ore.

Customer Ownership Committee; chairman: D. G. Tyree, The California Oregon Power Company, Medford, Ore.

Committee on Co-operation With Educational Institutions; chairman: R. M. Boykin, Puget Sound Power & Light Company, Seattle, Wash.

Committee on Employees' Relations With the Industry; chairman: Gen. H. G. Winsor, Puget Sound Power & Light Company, Seattle, Wash.

Committee on Employees' Relations with the Public; chairman: Dr. Adam S. Bennion, Utah Power & Light Company, Salt Lake City, Utah.

Committee on Relations With Financial Institutions; chairman: C. M. Brewer, Mountain States Power Company, Medford, Ore.

Essay Contest Committee; chairman: G. L. Myers, Pacific Power & Light Company, Portland, Ore.

Public Speaking Committee; chairman: G. L. Myers.

Women's Committee; chairman: Mrs. Gertrude McDevitt, Idaho Power Company, Boise, Idaho.

To plan the work for 1930, the executive committee of the Public Relations Section met in Portland, Nov. 15, 1929. Reports were heard from all committee chairmen, and a thorough discussion of the year's work and the activities of the various committees was had.

Because the N.E.L.A. is holding its 1930 convention in San Francisco, the Northwest association will not hold its usual convention, and it was deemed advisable for this Section to concentrate on a public speaking contest, an essay contest, and the women's committee work. It was the thought of the executive committee that these projects would supply sufficient incentive for employee effort during the year, and would carry out the purpose of the Section most effectively.

Inasmuch as the activities of the public speaking and essay contest committees are unfinished, no reports for these committees have been prepared at this time. These reports will be submitted for later publication, after results of the public speaking and essay contests are known. Finals of the public speaking contest are to be held in Portland, May 17.

Brief reports of the committees now ready to publish their reports follow. Other committees will report later.

[1] Executive Committee: R. B. King, chairman; W. H. Ude, vice-chairman; A. S. Bennion, R. M. Boykin, C. M. Brewer, L. R. Coffin, J. P. Lottridge, W. B. MacDonald, Mrs. Gertrude McDevitt, G. L. Myers, P. M. Parry, W. P. Strandborg, D. G. Tyree, H. G. Winsor.

ADVERTISING AND PUBLICITY COMMITTEE

*Advertising and Publicity**

IT WAS the sense of the executive committee of the the Public Relations Section at its meeting in Portland in the fall of 1929 that the most effective work for the advertising and publicity committee this year would be to arouse interest in the 1930 Convention of the N.E.L.A. to be held in San Francisco, June 16-20.

With that idea in mind the committee has been acting in co-operation with the N.E.L.A. convention publicity committee of which the chairman is a member. The committee also has co-operated with the N.E.L.A. convention transportation committee and various conferences have been held with the passenger traffic representatives of the leading trans-continental railroad systems with a view of having them do everything in their power to induce convention delegates from other sections of the country to route their trips

* Report of the advertising and publicity committee. W. P. Strandborg, Pacific Northwest Public Service Company, chairman.
The California Oregon Power Company: H. L. Bromley.
Idaho Power Campany: E. C. Kiersted.
Puget Sound Power & Light Company: R. G. Foster.
Utah Power & Light Company: M. L. Cummings, Jr.
The Washington Water Power Company: E. J. Crosby.

to or from the San Francisco convention, via the Pacific Northwest.

At a meeting of the N.E.L.A. publicity committee held in San Francisco early in March, it was decided to have the paid publicity manager undertake to direct all the major publicity activities relating to the convention, and he was instructed to secure local publicity material and photographs for publicity purposes from all the leading cities of the Pacific Coast, and to work directly in contact with the newspapers, magazines, trade and business publications, company house organs and to employ such other means as would most effectively arouse the highest interest in the convention.

These plans are being carried out. Radio broadcasting is to be used, and an extensive national hookup, or perhaps two, also will be used for the purpose of attracting convention delegates to see the whole Pacific Coast while on their trip.

Members of this committee have been asked to cooperate in every way possible with the local committees on reception and entertainment in all cities which will be visited either by special trains or by small groups of delegates. Reports from various members of the committee indicate that they are engaging in this line of activity.

The publicity manager at San Francisco has arranged to keep in contact with the individual members of this committee. He will supply them with all such material and information as will be helpful in making the convention attendance satisfactory. At the same time he will help to give the visiting delegates a rousing reception and memorable entertainment as they visit the cities in our jurisdiction.

Much of the detailed work of this committee is to be done between now and the convention, and it is confidently believed that our efforts will be successful.

COMMITTEE ON EMPLOYEES' RELATIONS WITH THE INDUSTRY

*Employees' Relations With the Industry**

THE committee on employees' relations with the industry convened at Portland, April 3, 1930. The subject, "Public Contact Training," was introduced for discussion.

Procedure as followed was in accord with the request of the national industrial relations committee as outlined by the Chicago conference and included a full discussion of each of the 28 questions suggested for consideration.

It is the opinion of this committee that a basic plan of training should be inaugurated by the national committee and made available to member companies at an early date. Such a plan should embrace the fundamental requirements as outlined by the geographic division committees, devised and enlarged upon as indicated by future experience.

This committee believes that several years will be necessary to develop a public-contact training program which will accomplish the desired results. It is suggested that future committees named to continue study of the plan be selected with a view to retaining as many who are familiar with the subject as is possible.

As the problem of training will require a solution which must be made applicable to varied conditions involving both member companies and communities served, any plan to be successful and helpful must have flexibility as well as clearly stated missions. It is believed that such a plan is both feasible and desirable.

Some member companies have established and are now conducting a system of public-contact training. It would be helpful if a brief outline of the plans used and results attained, could be made available to other companies.

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* Report of the employees' relations with the industry committee. General H. G. Winsor, Puget Sound Power & Light Company, chairman.
The California Oregon Power Company: S. B. Bullis.
Eastern Oregon Power & Light Company: J. P. Lottridge.
Idaho Power Company: M. E. Hughes.
Mountain States Power Company: Walter Smith.
Northwestern Electric Company: S. B Clark.
Pacific Northwest Public Service Company: Marguerite Butler.
Pacific Power & Light Company: G. T. Bragg.

Conclusions of the Committee

1. That a systematic and comprehensive plan of public-contact training is essential to our industry.

2. That such a plan, to be successful and of greatest value to member companies, must embrace provisions for all vocational and geographical groups within each organization.

3. That in order to produce a clear picture of the situation and the problems involved in setting up a workable system of training, a survey is necessary; that the method employed in conducting such a survey can best be decided by a conference study in each company organization with due consideration given both to employee requirements and to the attitude of the public in each community.

4. That any plan to be made satisfactory must include:

(*a*) Individual contact problems such as:
1. Counter work (contacts within the office)
2. Telephone communications
3. Written communications
4. Contacts within the home or business establishment.

(*b*) Group contacts such as:
1. Fraternal organizations
2. Civic organizations
3. Social organizations.

5. That personal attributes should be emphasized in the basic principles of all training, including:
(*a*) Appearance
(*b*) Manner
(*c*) Speech
(*d*) Ability to give information clearly, intelligently and courteously
(*e*) Expression of interest in customers' problems
(*f*) Ability to understand and explain changes in method or procedure.

6. That any plan recommended by the national committee be basic in its principles and application, and that it should be constructed in such a manner as to encourage its development in all member organizations regardless of size or location.

7. That whenever any plan is proposed which ap-

parently is acceptable to member companies an establishment be provided for the purpose of teaching the basic principles involved either through the medium of correspondence or direct instruction to groups of selected employees.

8. That the initial effort in the dissemination of instruction in connection with any proposed plan be applied to training of supervisors.

9. That, in each company organization, the authority and responsibility of planning in detail the training courses or system be delegated to an individual or group of individuals qualified by experience or intimate knowledge of the problems involved, and that the function so established receive the whole-hearted support of all executives and other supervisors.

10. That the results of all plans which are put into effect by member companies be reported semi-annually to a committee in each geographic division, these reports to form a basis for consolidated reports to be made to the national committee for its use in determining changes which it is desirable to make in the basic plan.

WOMEN'S COMMITTEE

*Women in the Industry**

THE women's committee of the Northwest geographic division consists of thirteen chairmen of local women's committees, two members-at-large, a chairman on the safety committee, and a home service chairman.

Local Committee Meetings

Just two of the thirteen local chairmen do not have committee meetings, because the women in their territories are widely scattered, but they are very active in sending literature and information to these women and keeping them well informed on the utility business. Some of the active committees are separated into divisions with subchairmen holding regular meetings.

Meetings vary in different communities, but always are held once a month. Most of them are held on company time and consist of morning, luncheon, afternoon and dinner meetings. Only one committee meets at night and the chairman of that one has a hard time with attendance. Every committee has side meetings on their own time in which they benefit themselves. Physical education, cooking, first aid, public speaking, sewing and art are some of their activities.

Every meeting program has at least one educational number that gives the women information on what their company is doing and also affords a medium of exchange of ideas. Each meeting then has a social number. These programs put on by employees give the women a chance to appreciate the talents of their fellow workmen and establish a social relationship that has real human value.

Public speaking is one of the "pets" of the Northwest. There are five committees holding public speaking meetings once a week.

Home Service and Safety Departments

Through the home service departments and with fine first aid classes and clever saleswomen, we get a great deal of public contact both collectively and individually. The first aid classes are very popular and their teams demonstrate for many civic organizations and in the public schools. The women have been sent out, by request, to teach classes in school how to read meters and also to demonstrate appliances.

The home service department is of real value to rural customers, for to them it is an information bureau, not only on electricity and its ways and uses, but also on other matters of interest. We help them buy their pots and pans and tell them what length fashion says they should wear their skirts.

Every committee has done wonderful charity work, especially around Christmas time when they have joined the other civic organizations in taking care of needy families. In fact, the ingenious methods these women have used to raise money and the success they have had makes them the envy of all high financiers.

Expansion Recommended

Wholesale distributors in the different states would be a welcome addition to our women's committee work. They all have home economists who travel extensively, and most of them hire from ten to twenty women employees. These women employees are not actively engaged in sales and do not get the information about their merchandise and about the utilities they sell to. In the Idaho division, they have sold 3,327 ranges and a total of $1,100,000 of appliances in 1929. Employees of manufacturing concerns should know about such an electrical utility and its business relations and its service to the public, and how their merchandise pleases the general public.

* Report of the women's committee. Mrs. Gertrude McDevitt, Idaho Power Company, chairman.
The California Oregon Power Company: Mildred Knight.
Eastern Oregon Light & Power Company: Loy Wisdom.
General Electric Company: Martha O. Goldapp.
Grays Harbor Railway & Light Company: Esther Miller.
Idaho Power Company: Mrs. Amy Villa.
Mountain States Power Company: Estella Dorgan, Hazel Earl.
Northwestern Electric Company: Mrs. A. W. Angell.
Pacific Northwest Public Service Company: Marguerite Butler.
Pacific Power & Light Company: Gertrude Humphrey.
Puget Sound Power & Light Company: Mrs. Nell Laws.
Utah Power & Light Company: Charlotte Cummings.
The Washington Water Power Company: Edith L. Hedger, Mary K. Walsh.

CUSTOMER OWNERSHIP COMMITTEE

*Customer Ownership**

THE 1929-30 customer ownership committee held a meeting at Portland, April 10, 1930. Due to conflicting engagements, a full attendance was not secured but representatives of the following companies were present:

Pacific Northwest Public Service Corporation
Puget Sound Power & Light Company
Pacific Power & Light Company
Northwestern Electric Company
Mountain States Power Company
The California Oregon Power Company.

* Report of the customer ownership committee. D. G. Tyree, The California Oregon Power Company, chairman.
Idaho Power Company:: L. W. Brainard.
Pacific Northwest Public Service Company: E. G. Jarvis.
Pacific Power & Light Company: S. E. Skelley.
Puget Sound Power & Light Company: Dwight Ware.
Utah Power & Light Company: George B. Thomas.
The Washington Water Power Company: W. H. Ude.

TABLE I—Sale of Preferred Stock.

Name of Company	Security Sold	Par Value	Selling Price per Share	No. Shares Sold to Customers	No. Shares Sold to Employees	No. Shareholders Obtained	No. of These Already Shareholders
Puget Sound Power & Light Company	6% Preferred Stock	No par	$100	38,869	1,953	7,206	....
Portland Electric Power Company (now Pacific Northwest Public Service Company)	6% Preferred Stock	No Information	....	....	....	....	....
Washington Water Power Company	$6 Preferred Stock	No par	$102 (plus acc. div.)	27,400	5,118	4,969	1,500
Utah Power & Light Company	$6 Preferred Stock	No par	$101	8,833	3,763	3,497	2,238
Idaho Power Company	$6 Preferred Stock	No par	$100	9,288	955	1,935	600
The California Oregon Power Company	6% Preferred Stock	$100	$101	9,820	130	1,316	561
*Pacific Power & Light Company	7% Preferred Stock	$100	$100-$111	132	....	43	13
*Northwestern Electric Company	7% Preferred Stock	$100	None Sold	....	....	....	....
*Mountain States Power Company	7% Preferred Stock	$100	$100-$103	No Information	....	....	....

*These companies did not engage actively in the sale of preferred stock to customers and employees during 1929, but handled a few resales.

For the purpose of gaining information covering customer ownership activities of the various companies during the year 1929, a form of questionnaire was adopted which has since been completed by the various companies in the association. The data secured appear at the end of this report in tabulated form.

While not all of the companies in the Northwest Association had active customer ownership campaigns during 1929, it was the consensus of opinion that customer ownership is just as important to the industry now as it ever was, and that this activity should not be dropped or curtailed by any company in the association unless absolutely unavoidable.

Future Plans

The Pacific Northwest Public Service Corporation (formerly Portland Electric Power Company) plans on selling $4 first preferred stock of the Central Public Service Corporation (the parent organization) during 1930 and hopes to place $5,000,000 of this stock in the hands of its customers.

The Puget Sound Power & Light Company plans on selling about $5,000,000 of its 6 per cent preferred stock under the customer ownership plan in 1930.

The California Oregon Power Company plans on selling about $1,000,000 of its 6 per cent preferred stock during 1930 in the territory served by the company.

None of the other companies have reported any definite plans for campaigns, although all companies will redistribute stock which is turned back by the old stock holders.

Value of Customer Ownership

In addition to the information furnished by the various companies covering preferred stock campaigns in 1929, the following question was answered by each company: "What has the customer ownership plan accomplished for your company?"

One company states that this activity has improved the company's public relations through the friendly interest of new stockholders; that a knowledge of the company and of its problems was necessarily disseminated in carrying on sales work; that it develops company spirit among the employees.

Another company states that this plan has enabled the company to overcome readily any misunderstanding and adverse propaganda; that the friendliest communities are the ones where the most stock is held.

All companies were unanimous in stating that customer ownership increases good-will toward the company throughout the territory served.

In answer to the question: "What is your opinion as to the possibilities for sale of preferred stock of utility companies through the customer ownership plan during the coming year?" all companies expressed the opinion that the possibilities are excellent and that the sale of preferred stock on this plan could be carried on as successfully as ever during 1930.

Recommendations

The committee recommended that the companies take more advantage of their opportunities to show the public through their customer shareholders what is being done by the electric utility industry. Invite them to visit plants; arrange trips for them; take moving pictures showing the company systems from the air and give free shows; do everything possible to give stockholders and their friends a complete and realistic picture of the company system. Also bring them into contact with the company officials so that they will become personally acquainted and will realize that the company organization is led by men and women who are human beings like themselves.

The committee recommends that the companies continue using employees as much as possible in the distribution of securities on the customer-ownership plan.

The committee recommends that the security to be sold on this plan be a preferred stock wherever possible, as this sort of security does not fluctuate and cause the stockholder any anxiety as to his savings.

General Committee Report[1]

EDUCATIONAL COMMITTEE

*Educational Activities in the Northwest**

ENROLLMENT in N.E.L.A. educational courses in the Northwest geographic division in the twelve-month period ending March 31, 1930, as compared to the enrollment for the previous twelve-month period was as follows:

	1930	1929
Practical electricity	51	30
Elementary accounting	11	4
Advanced accounting	32	5
Lighting sales	5	1
Merchandise sales	14	7
Power sales	10	2
Electrical metermen	21	19
	144	68

The current year's enrollments were divided among companies as follows:

Puget Sound Power & Light Company	62
Idaho Power Company	33
The Washington Water Power Company	17
Northwestern Electric Company	8
Pacific Northwest Public Service Company (Pepco)	6
Pacific Power & Light Company	5
Eastern Oregon Light & Power Company	5
The California Oregon Power Company	3
Utah Power & Light Company	1
Helena Gas & Electric Company	1
Montana Power Company	1
Peoples West Coast Hydro-Electric Corporation	1
Salmon River Power Company	1
Total	144

A change has been made in the period covered by the accompanying tabulations as against the period reported in last year's report in that this year the twelve-month period runs from April 1, 1929 to March 31, 1930, inclusive, instead of from March 1 to Feb. 28. The 1929 figures reported above have been changed to conform to this time period for comparative purposes.

One of the steps taken by the national committee during the past year has been to agree to make available to Class A member companies that have organized class work in charge of instructors, the texts of the N.E.L.A. courses without the correspondence service at a greatly reduced price.

The Northwest educational committee held one meeting during the year in Portland, Ore., on April 3, 1930. Among subjects discussed was that pertaining to the evils attendant on high-pressure solicitation of company employees by representatives of the commercial correspondence schools. It was recognized that very often an employee was induced to subscribe to a course for which he would not have sufficient background of education and later would drop the course and suffer a monetary loss, or that he would be sold a course that did not measure up to other courses available. However, it sometimes develops that some courses offered by one of the commercial companies is better suited to the employee's needs than any of the N.E.L.A. courses. This discussion led to the adoption of the following resolution:

Resolution

Resolved, That it seems highly desirable from the standpoint both of the company and the employee that some control be exercised by the company over its employees' educational endeavors and it is suggested that employees be urged to seek the advice of some delegated person in their organization—personnel director, department head or district manager—prior to subscribing for any course whatever, whether an N.E.L.A. course or one from one of the commercial companies.

It was further determined at this meeting that the educational committee as such should not attempt to set up elaborate plans for the promotion of the N.E.L.A. courses in this territory. This was found to be a problem for the individual company involving company policy which should be left to the company's representative on the committee. The continuance of the committee, however, was deemed advisable, and the chairman was urged to continue to send out to the individual members all of the information on N.E.L.A. courses made available by the national committee.

Representation Desirable

It is recommended that all companies interested in maintaining a certain amount of control over their employees' educational endeavors be represented on this committee, and such companies not now represented are urged to appoint a representative.

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* Report of the educational committee. Berkeley Snow, *Electrical West*, chairman

The California Oregon Power Company: H. L. Bromley.
Eastern Oregon Light & Power Company: J. B. Brokaw.
Idaho Power Company: E. C. Kiersted.
Mountain States Power Company: Z. E. Merrill.
Northwestern Electric Company: R. W. Faville.
Pacific Northwest Public Service Company: George Sullivan.
Pacific Power & Light Company: G. T. Bragg.
Puget Sound Power & Light Company: H. G. Winsor.
Utah Power & Light Company: M. L. Cummings, Jr.
The Washington Water Power Company: W. H. Ude.